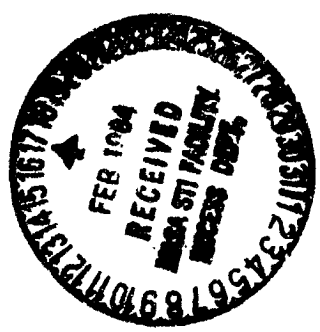
CR-171 741
c.1



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SPACE SHUTTLE ICE SUPPRESSION SYSTEM VALIDATION

TEES-TR-4587-82-01

VOLUME II

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INFLUENCE OF TEST PARAMETERS ON FLOW VISUALIZATION PATTERNS

1.0.0 Nominal Nozzle Arrangement

1.1.0 No Wind Condition (Lab Runs)

1.1.1 Influence of Nozzle Size

The influence of nozzle size is dramatically illustrated in lab runs A, B and C. It appears that increasing the size of the nozzle provides better coverage of ogive and mid-region of the ET. It is interesting to note, however, that for the bottom region of the ET coverage seems to decrease with nozzle size. This can be explained if both the assymmetry of the lower set of nozzles and the blockage provided by the Orbiter aft-support structure are taken into account.

1.1.2 Influence of Nozzle Pressure

Runs A, D and G or B, E and H or C, F and I may be used to study nozzle pressure effects. They all seem to indicate that, as expected, coverage improves with nozzle pressure. At 20 psia and with nominal size nozzle, the low velocity region at the bottom half of the ET seems to be large.

1.2.0 Wind Tunnel Runs

1.2.1 Reference Runs (13-14-17), NO JETS, 20 KT

Both 338° and 202° show significant velocities in the Orbiter-ET Gap. The flow pattern at 202° is consistent with what would be generated by impinging wind. The flow at 338° is consistent with patterns that would be generated in a wake type of flow. It appears that for both wind directions the velocities around the ogive are also significant. Run 17 (112°) shows some interesting results. It appears that most

of the tank is subject to high wind velocities. However, the lower section of the Orbiter-ET Gap seems to be shielded from the wind by the wings of the Orbiter, resulting in a low velocity region.

1.2.2 Wind Velocity Effects at 112° (Runs 1, 18, 19)

The runs at 20 and 30 KT (1 and 18) show adequate flow coverage of the Orbiter-ET Gap. For the 30 KT case the streamlines seem to be horizontal indicating that the incoming wind is dominant. The Orbiter streamline patterns are remarkably similar for runs 19 and 1 (10 KT and 20 KT). Such similarity is not present on the ET surface. The inclined streaklines on the upper section of the ET seem to indicate that the flowfield in that region is dominated by the jets. The lower half appears not to be subject to high velocities.

1.2.3 Wind Velocity Effects at 202° (Runs 2, 15, 16)

Similar conclusions can be derived at this wind angle. The combination of jets and wind appears to create significantly high velocities in the ET-Orbiter Gap at 20 and 30 KT and lower velocities at 10 KT. These lower velocities may still be significant as can be inferred from Run 2 where the ET ogive is subject to velocities much higher than the nominal 20 KT and yet no oil flow pattern can be observed.

1.2.4 Wind Velocity Effects at 338° (Runs 3, 4, 5)

Velocities in the ET Orbiter Gap seem to be high for all three wind speeds. It appears that while the velocity field is dominated by the jets at 10 KT, it is the effect of the incoming wind that is dominant at 20 and 30 KT. No significant jet induced flow patterns are discernable on the ET ogive for any of the 3 wind velocities.

1.2.5 Nozzle Pressure Effects at 20 KT and 338° (Runs 3, 6, 7)

It appears that the flowfields generated by the 32 psia (Run 3) and

27 psia (Run 7) jets are not very different. The most obvious differences can be observed at the back of the ET and at the mid-region of the ET-Orbiter Gap. On the other hand, the 20 psia run (Run 6) seems to indicate that induced velocities are much lower and that the jets fail to penetrate the wind and reach the ET.

1.2.6 Nozzle Azimuth Effects at 20 KT and 338° (Runs 3, 8, 9)

The comparison of Runs 3, 8 and 9 shows the ability to modify nozzle azimuth as a function of wind velocity is a very effective way of optimizing the flowfield. An azimuth of -15° seems to lead to a significantly improved flow field when compared to 0° or -30°. None of the 3 angles, however, seems to have an influence on the ogive flowfield.

1.2.7 Wind-Azimuth Interaction (Runs 9, 10)

Study of Runs 9 and 10 indicates that with a -30° azimuth setting at 32 psia nozzle pressure, the jets provide adequate coverage of the ET-Orbiter Gap for both 20 and 30 KT winds. It seems, however, that the ogive is not significantly covered specially at 30 KT.

1.2.8 Pressure Influence on Wind Penetration at 30 KT at 338° (Runs 10, 11 and 12)

It is interesting to note that despite the wide range of nozzle pressures used in the three runs, the flowfields patterns are remarkably similar, not only on the Orbiter surface but also at the ET-Orbiter Gap. It appears that nozzle pressure effects can only be observed through the appearance of a low velocity region close to the feedline on the mid-tank region and a decrease in the inclination of the streamlines as nozzle pressure decreases. None of the nozzle pressures seems to provide adequate coverage of the ogive. The flow visualization results strongly suggest that the wind dominates the flowfield.

2.0.0 Marshall Space Flight Center Configuration

A limited number of runs were made to study this configuration. Special care should be taken when comparing the photographs of this group of tests with those of the nominal configuration, as the oil mixture used here was of a lower viscosity. The use of lower viscosity oil was needed to provide good quality flow patterns with the lower nozzle exit velocities prescribed by the Marshall configuration.

2.1.0 No Wind Condition (Runs 44 and 47)

The differences between the flow fields generated by large (R 44) and small (R 47) nozzles are not very significant as far as ET coverage is concerned. In both cases the flow separates at the same location on the ogive. Feedline coverage appears to be worse than that of the nominal arrangement.

2.2.0 Wind Velocity Effects at 338^{0}, High Flow Rate (Runs 45 and 46)

The coverage of the ET-Orbiter gap seems to be good. Feedline coverage seems better at 7 KT than at 20 KT (it appears that some flow crosses over under the feedline). Ogive coverage is not good at 20 KT, it is better at 7 KT. Recirculation eddies form ahead of the Orbiter nose (they could clearly be seen while the tests were being conducted), and give a clear indication of the extent of the coverage in the vertical direction.

3.0.0 Norman Engineering Configuration (Runs 48, 49, 50, 51, 52, and 53)

As in the case of the Marshall configuration, the Norman Engineering configuration was studied using a mixture of lower viscosity than that used in the Nominal configuration and this fact should be taken into account when studying the photographs. The flow patterns generated by this configuration are consistent with those generated by the Nominal configuration and no significant differences can be found. It is important to note that, as in the nominal arrangement, this configuration provides no Ogive coverage for a

20 KT wind.

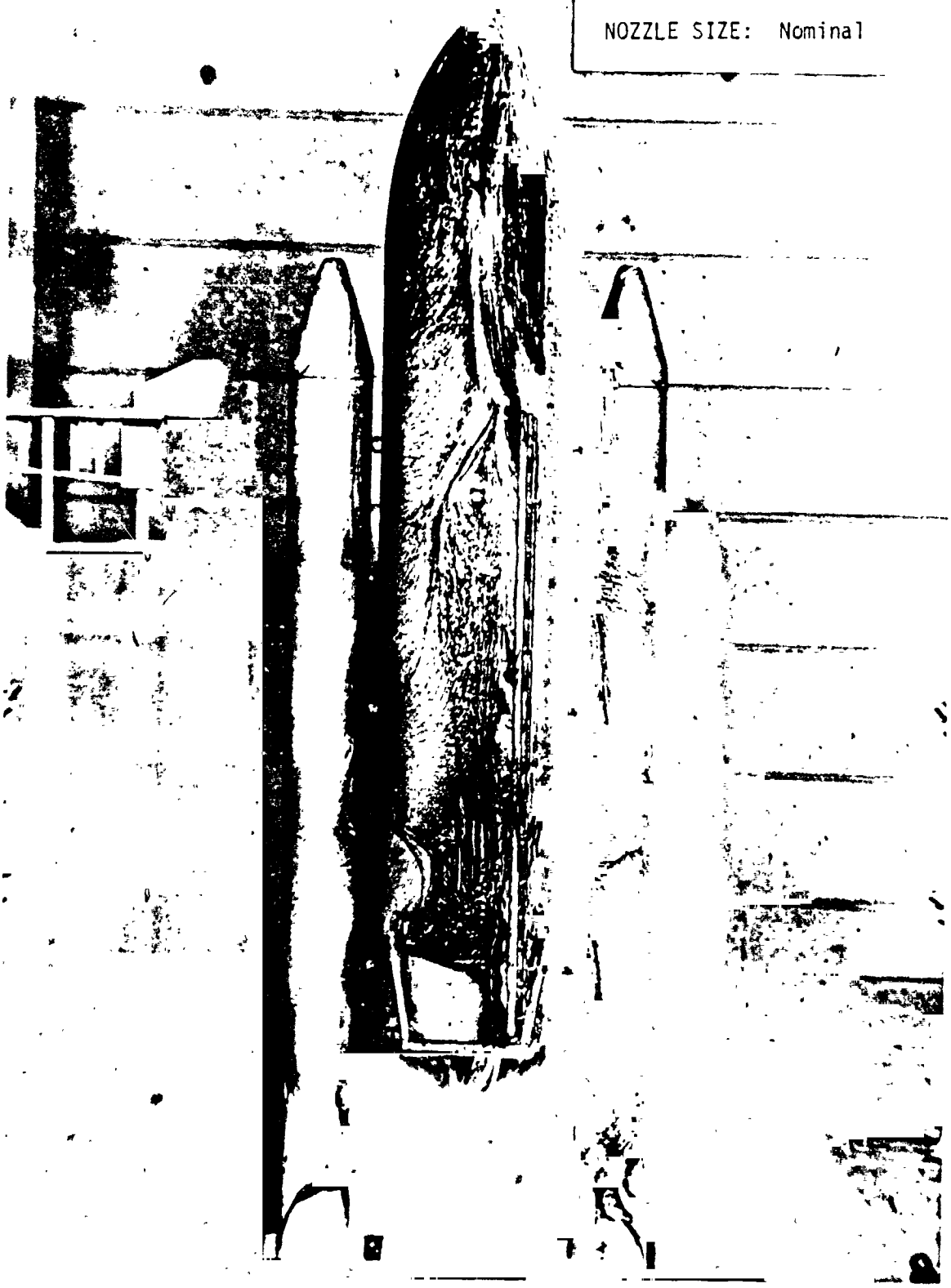
ORIGINAL PAGE IS
OF POOR QUALITY

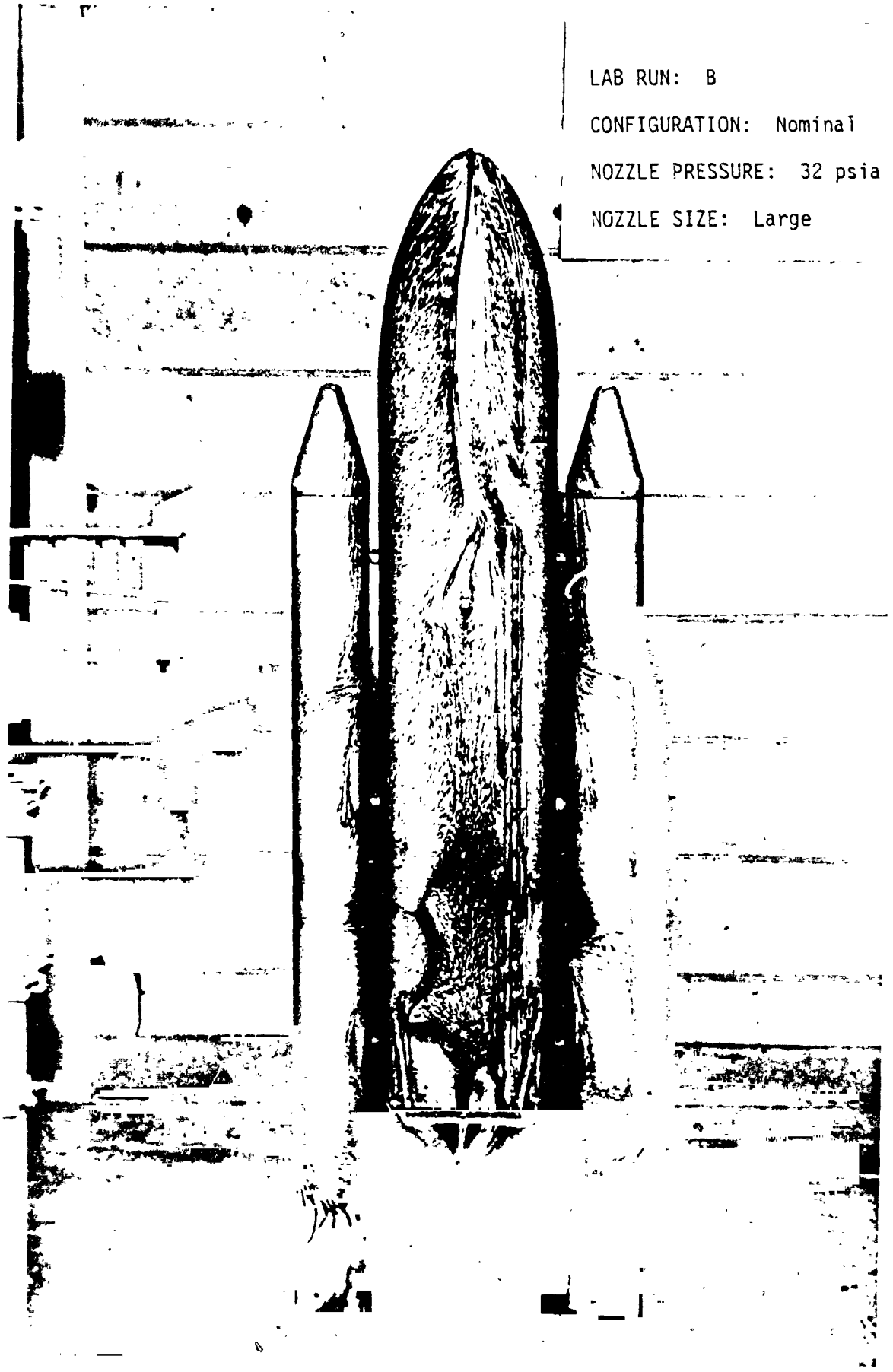
LAB RUN: A

CONFIGURATION: Nominal

NOZZLE PRESSURE: 32 psia

NOZZLE SIZE: Nominal



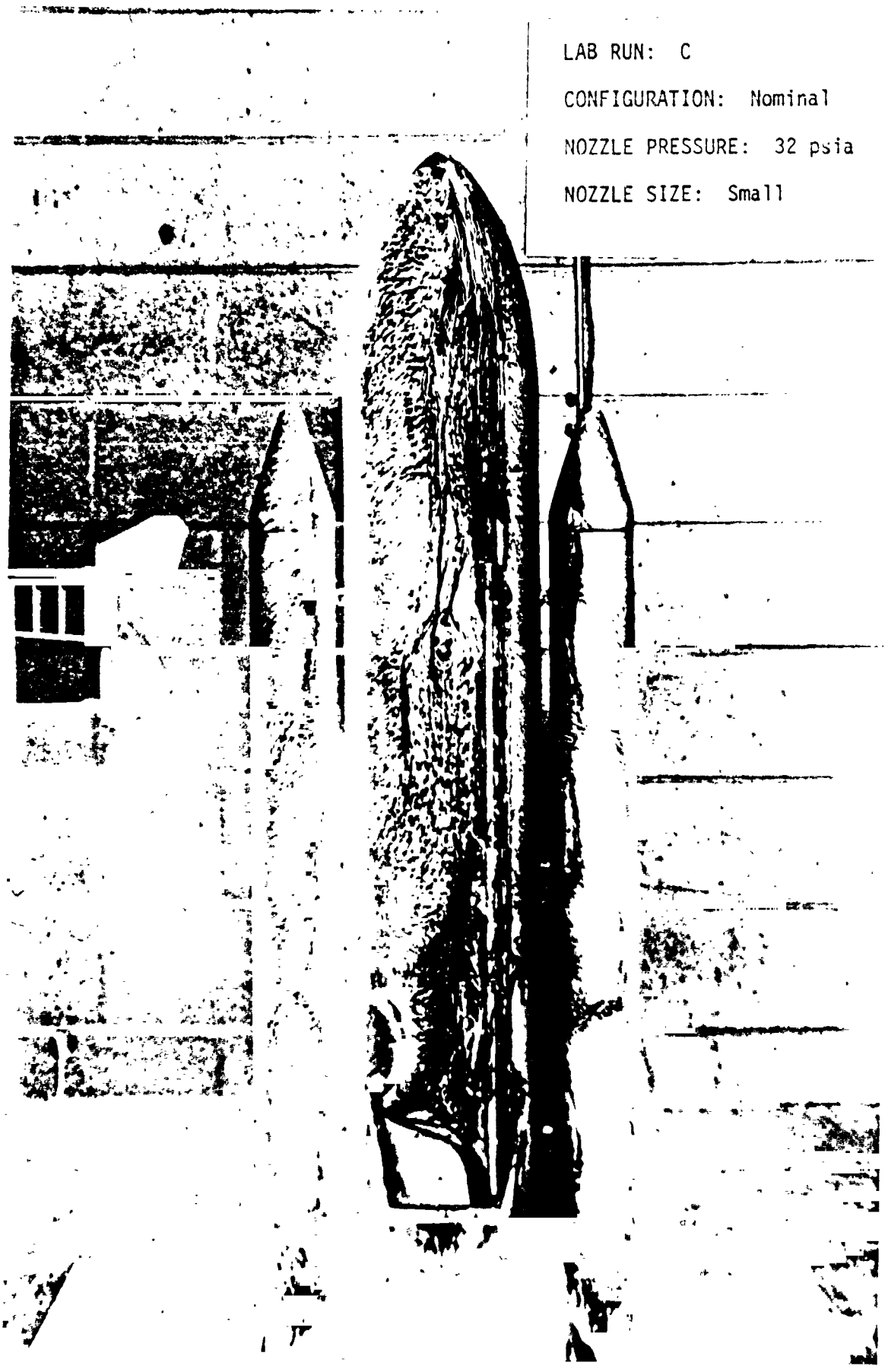


LAB RUN: B

CONFIGURATION: Nominal

NOZZLE PRESSURE: 32 psia

NOZZLE SIZE: Large



LAB RUN: C

CONFIGURATION: Nominal

NOZZLE PRESSURE: 32 psia

NOZZLE SIZE: Small

ORIGINAL PAGE IS
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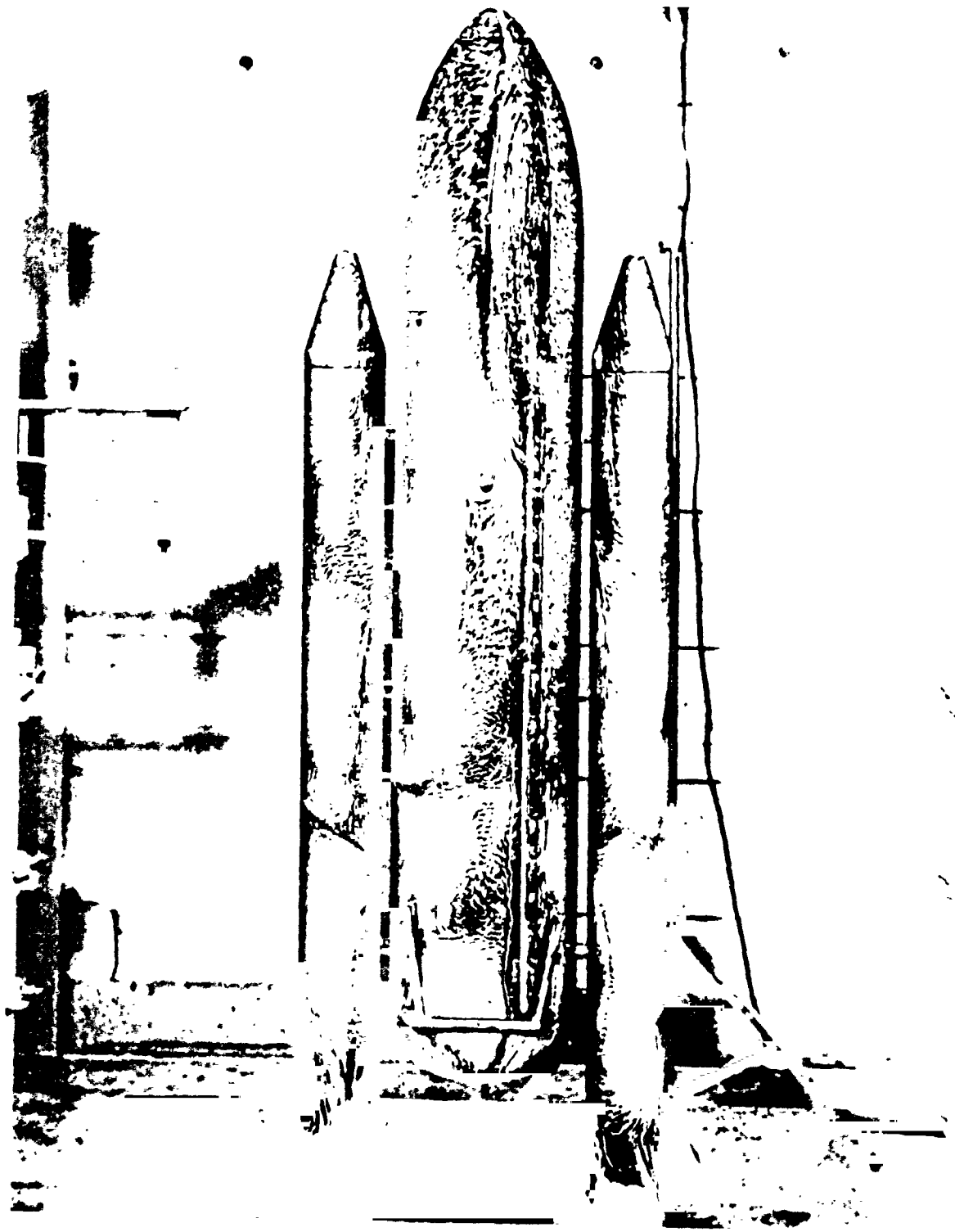
LAB RUN: D

CONFIGURATION: Nominal

NOZZLE PRESSURE: 27

NOZZLE SIZE: Nominal

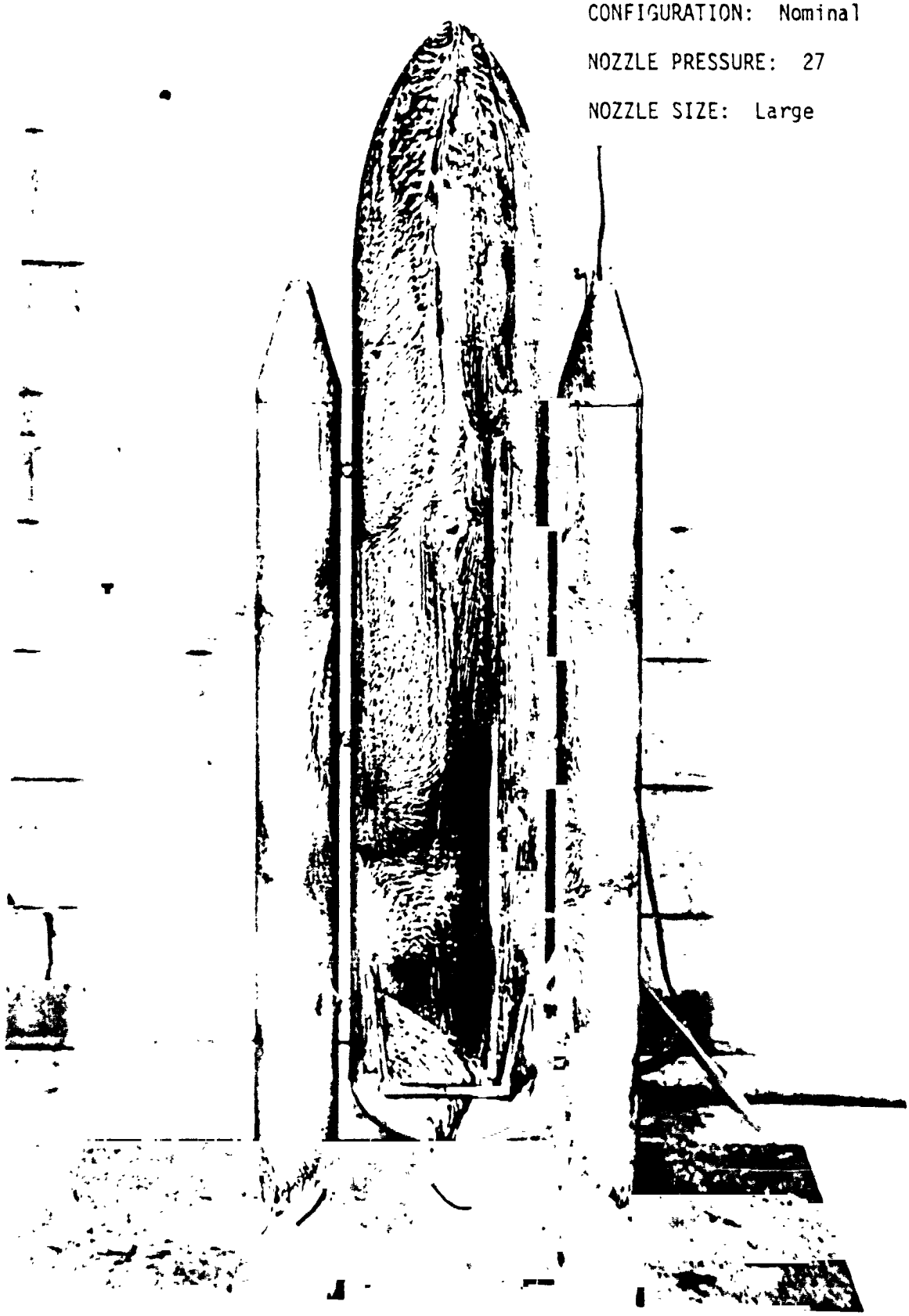


LAB RUN: E

CONFIGURATION: Nominal

NOZZLE PRESSURE: 27

NOZZLE SIZE: Large

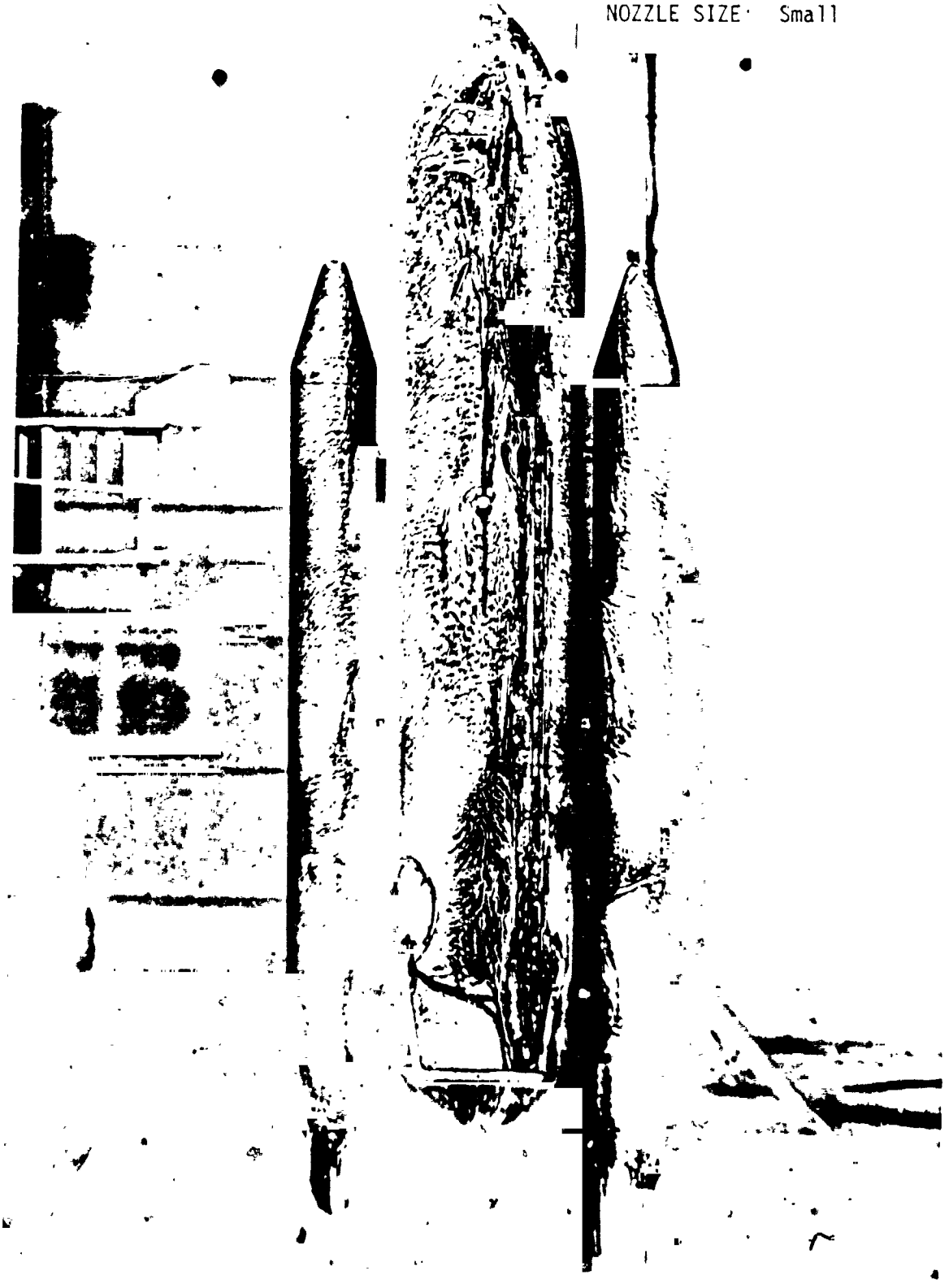


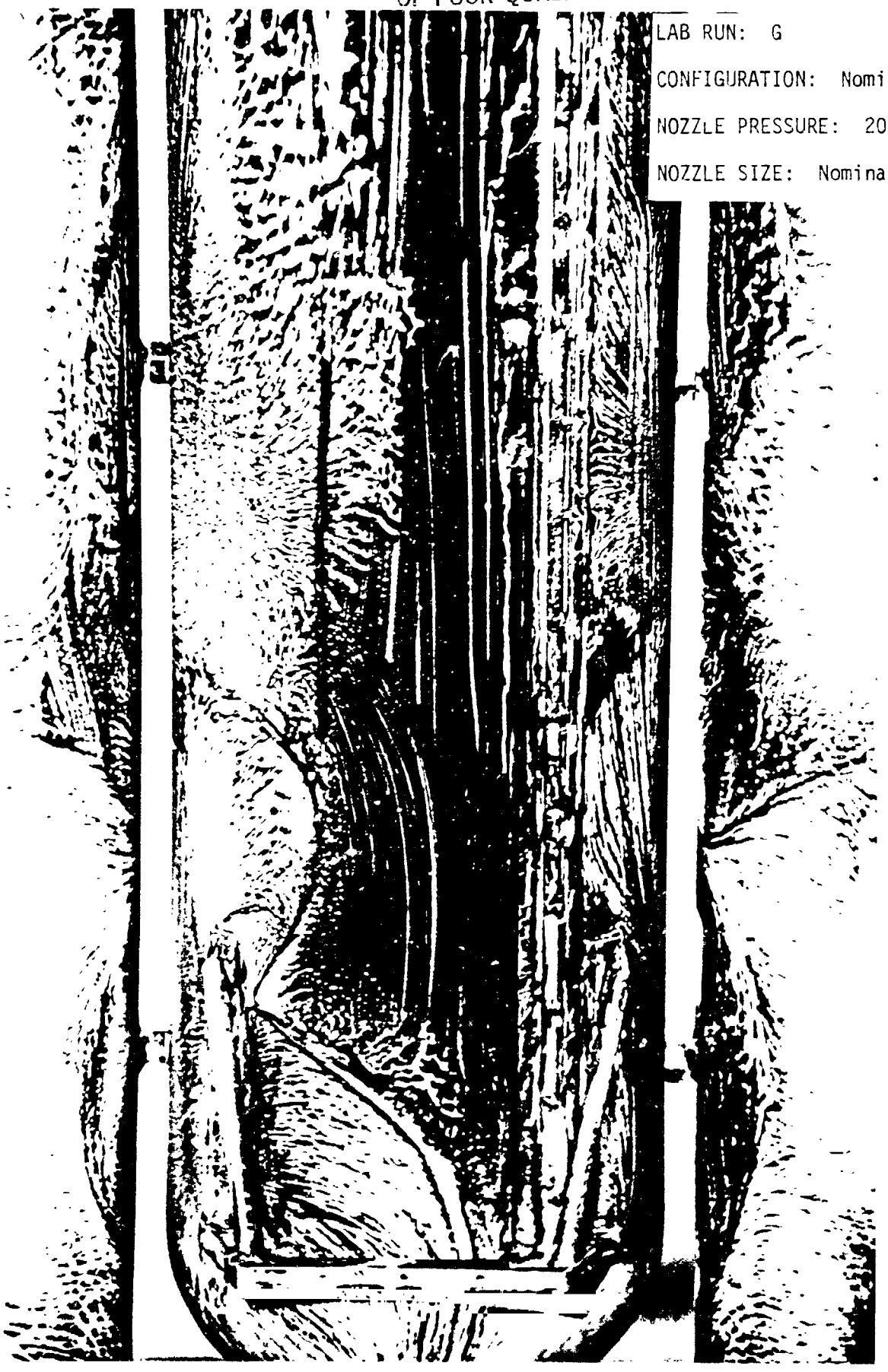
LAB RUN: F

CONFIGURATION: Nominal

NOZZLE PRESSURE: 27

NOZZLE SIZE: Small





LAB RUN: G

CONFIGURATION: Nominal

NOZZLE PRESSURE: 20

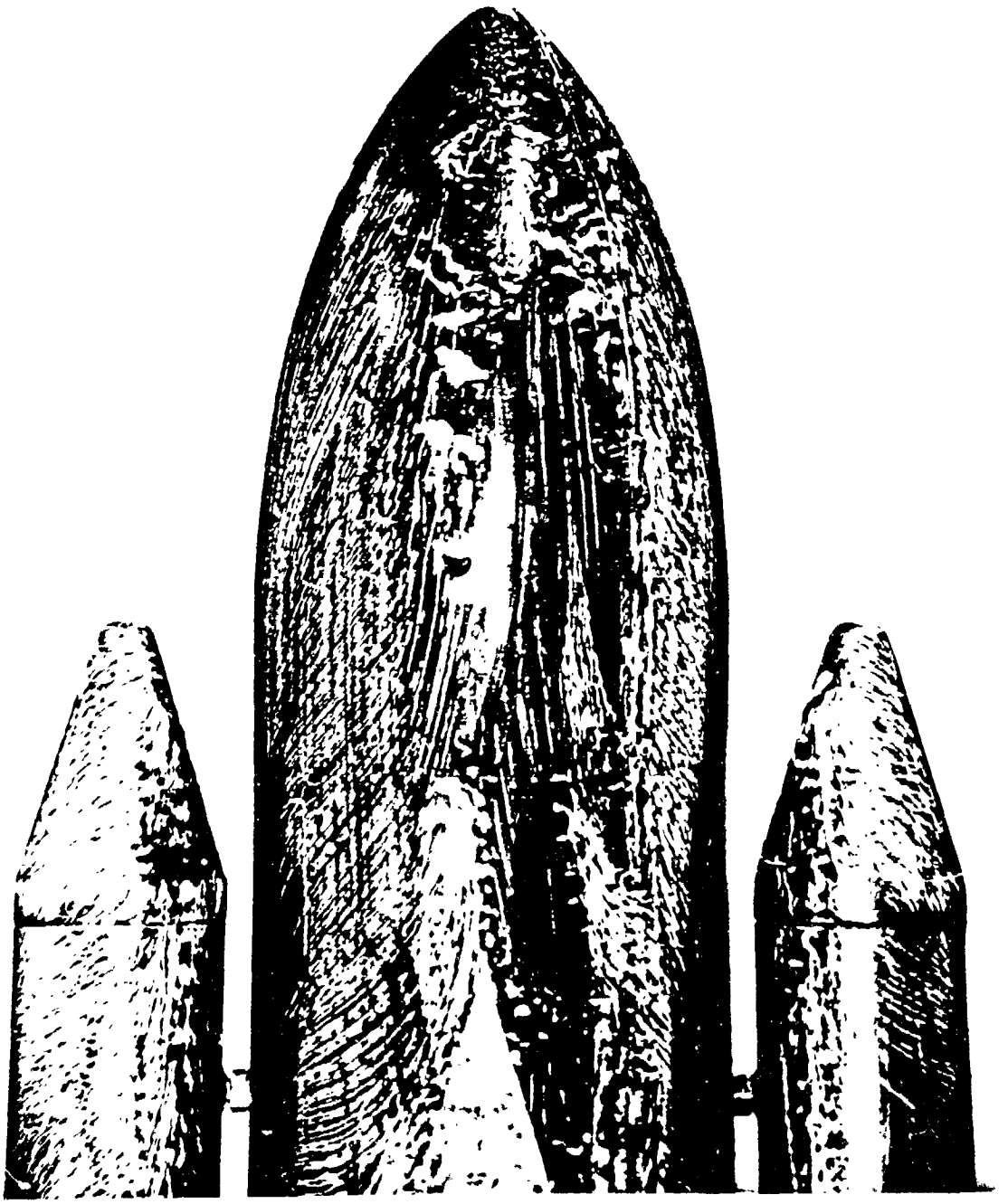
NOZZLE SIZE: Nominal

LAB RUN: G

CONFIGURATION: Nominal

NOZZLE PRESSURE: 20

NOZZLE SIZE: Nominal



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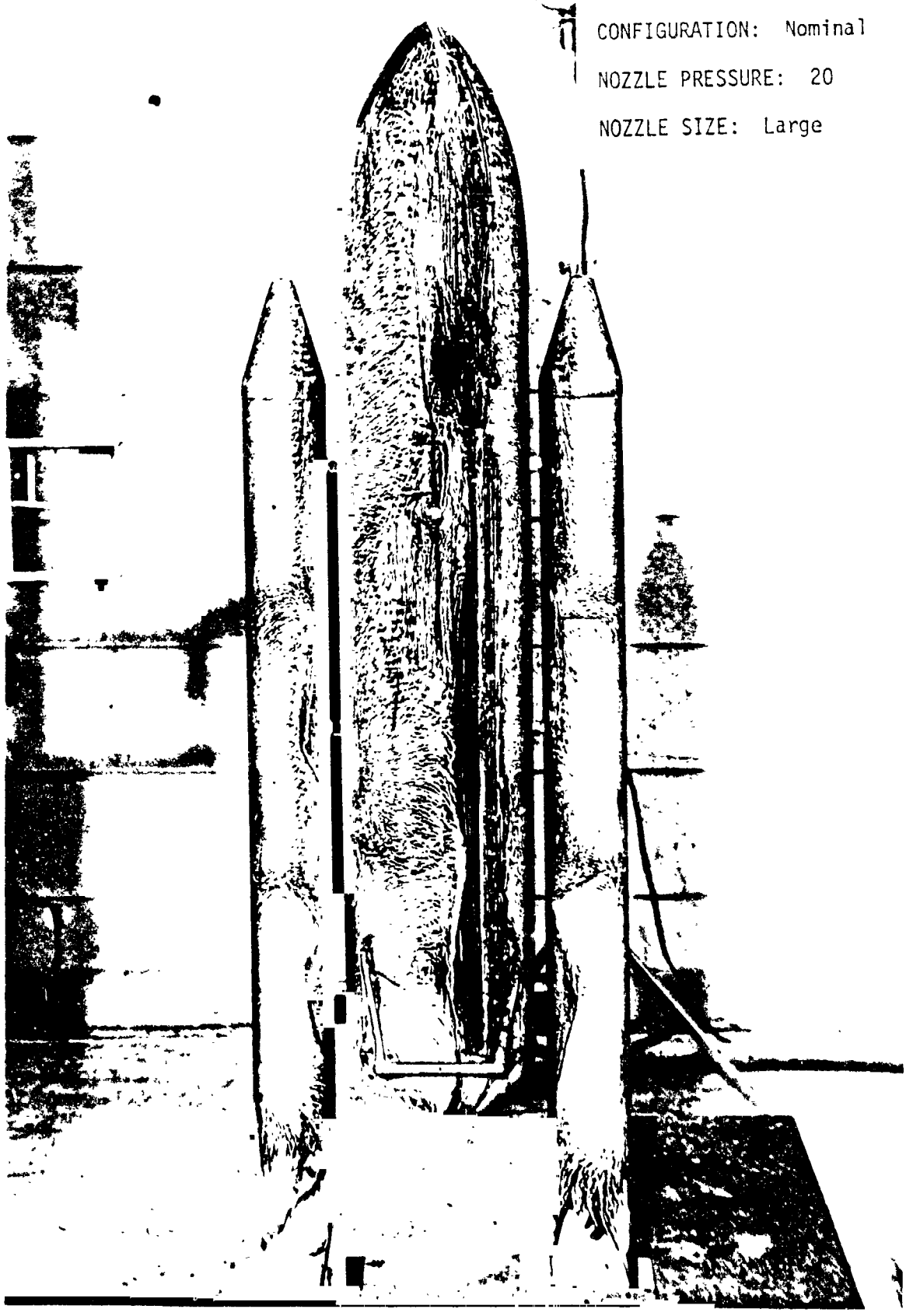
CONFIGURATION: Nominal

NOZZLE PRESSURE: 20

NOZZLE SIZE: Large

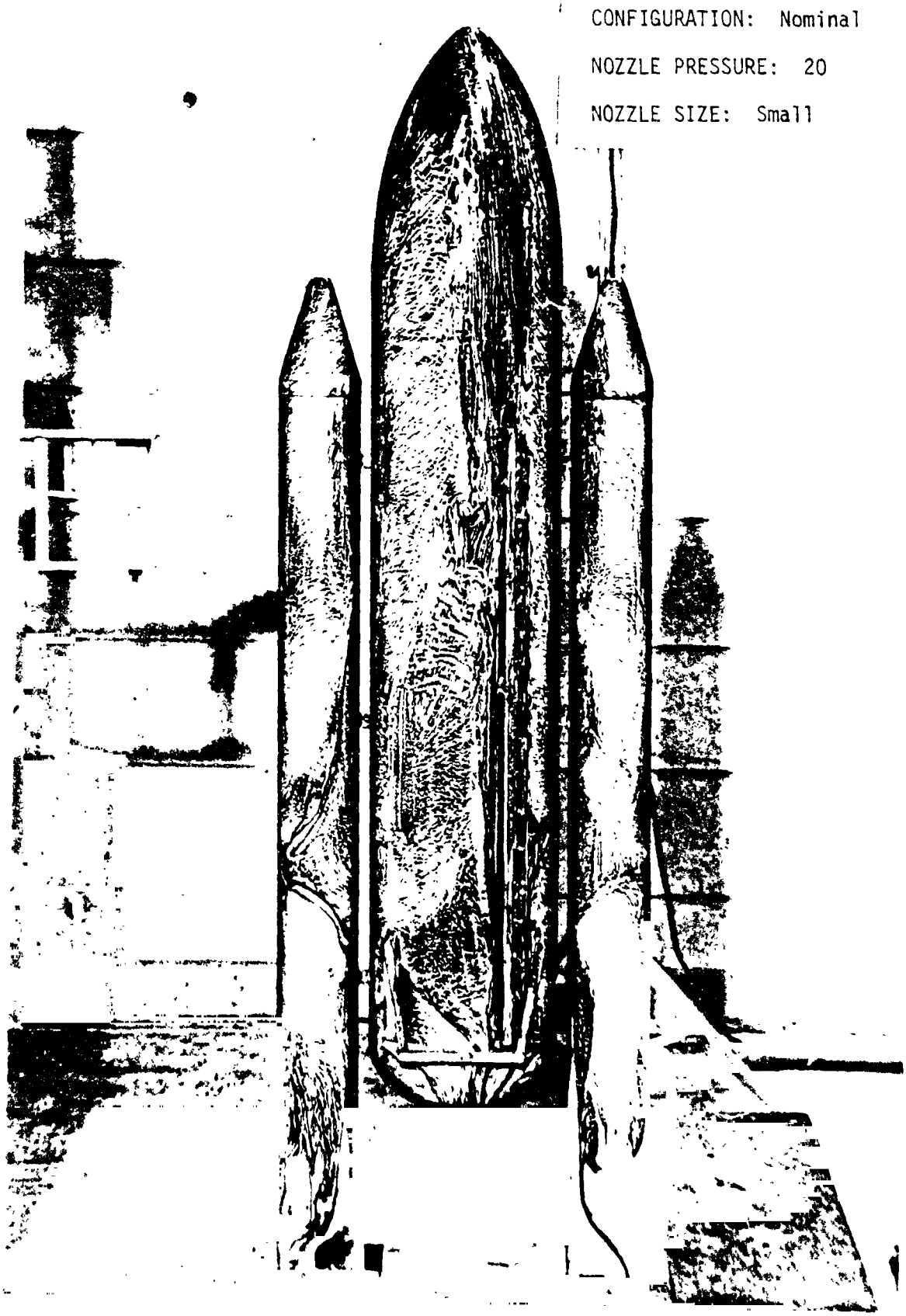


LAB RUN: I

CONFIGURATION: Nominal

NOZZLE PRESSURE: 20

NOZZLE SIZE: Small



RUN NO. 1

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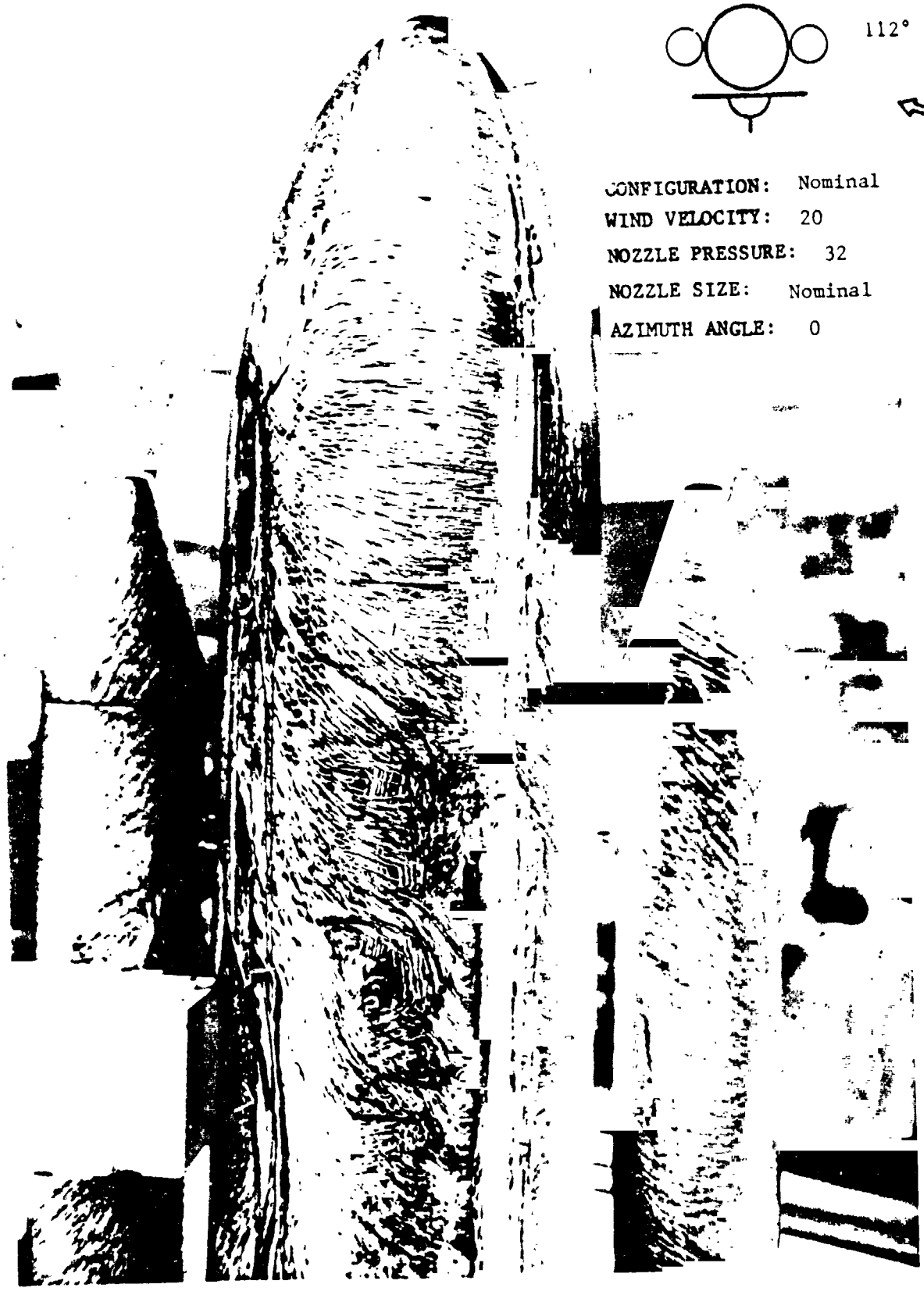
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN NO. 1



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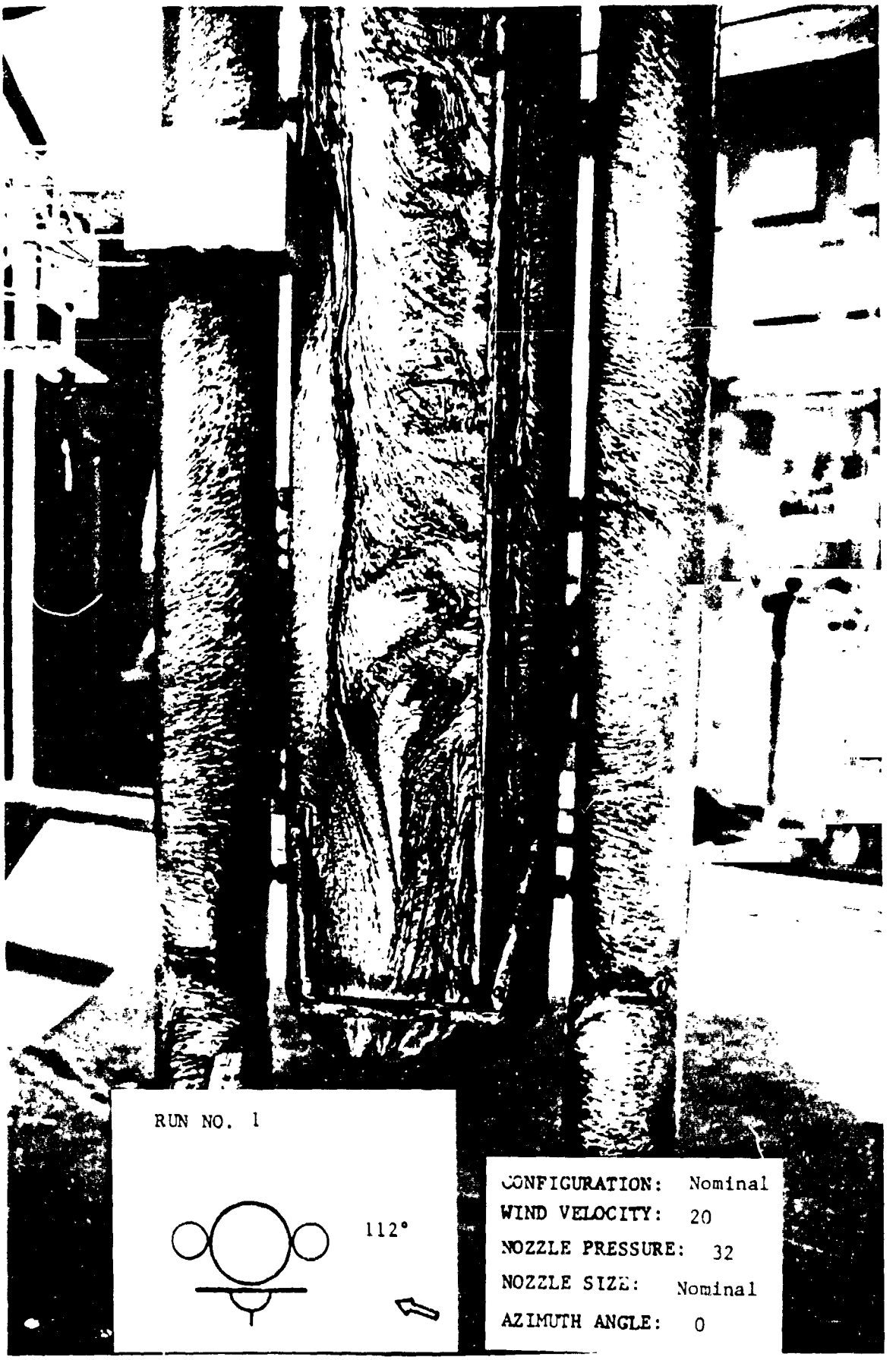
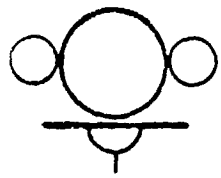


RUN NO. 1



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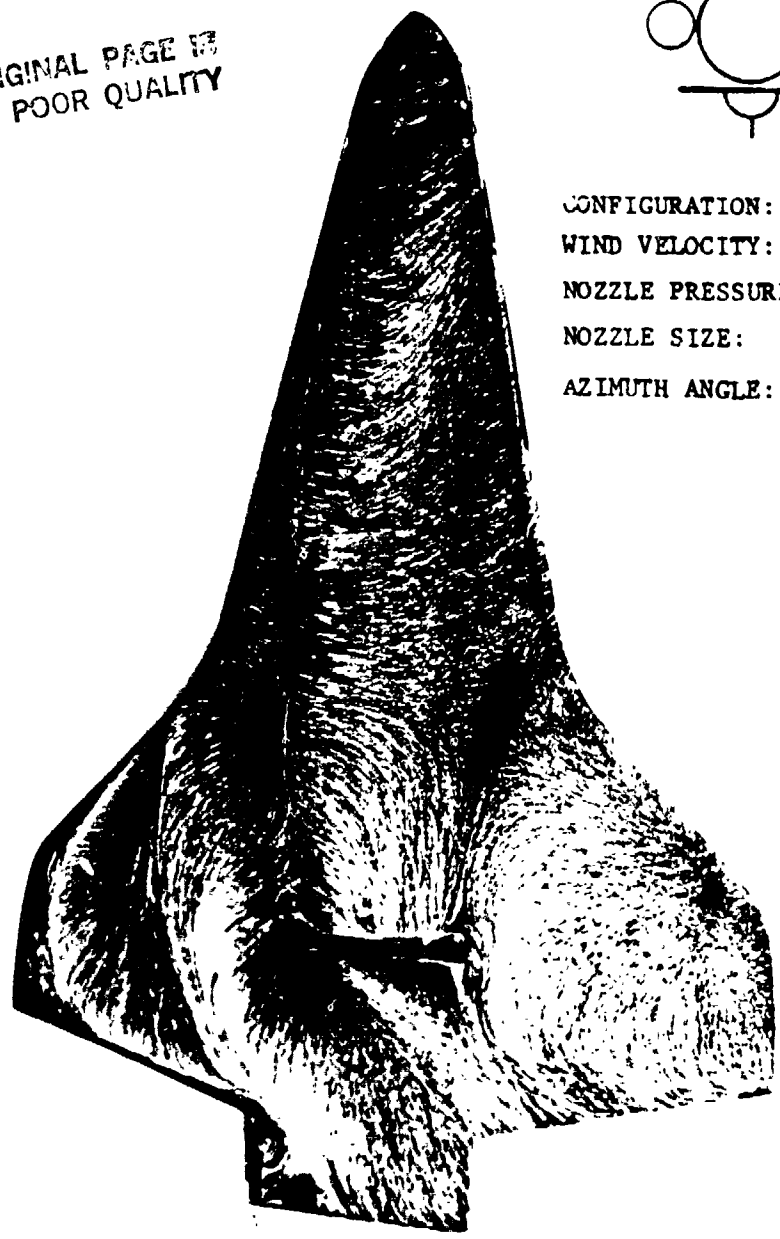
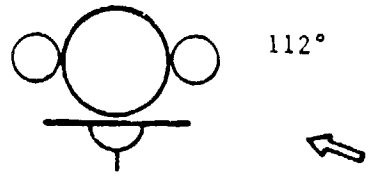
AZIMUTH ANGLE: 0

RUN NO. 1





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NOZZLE PRESSURE: 32
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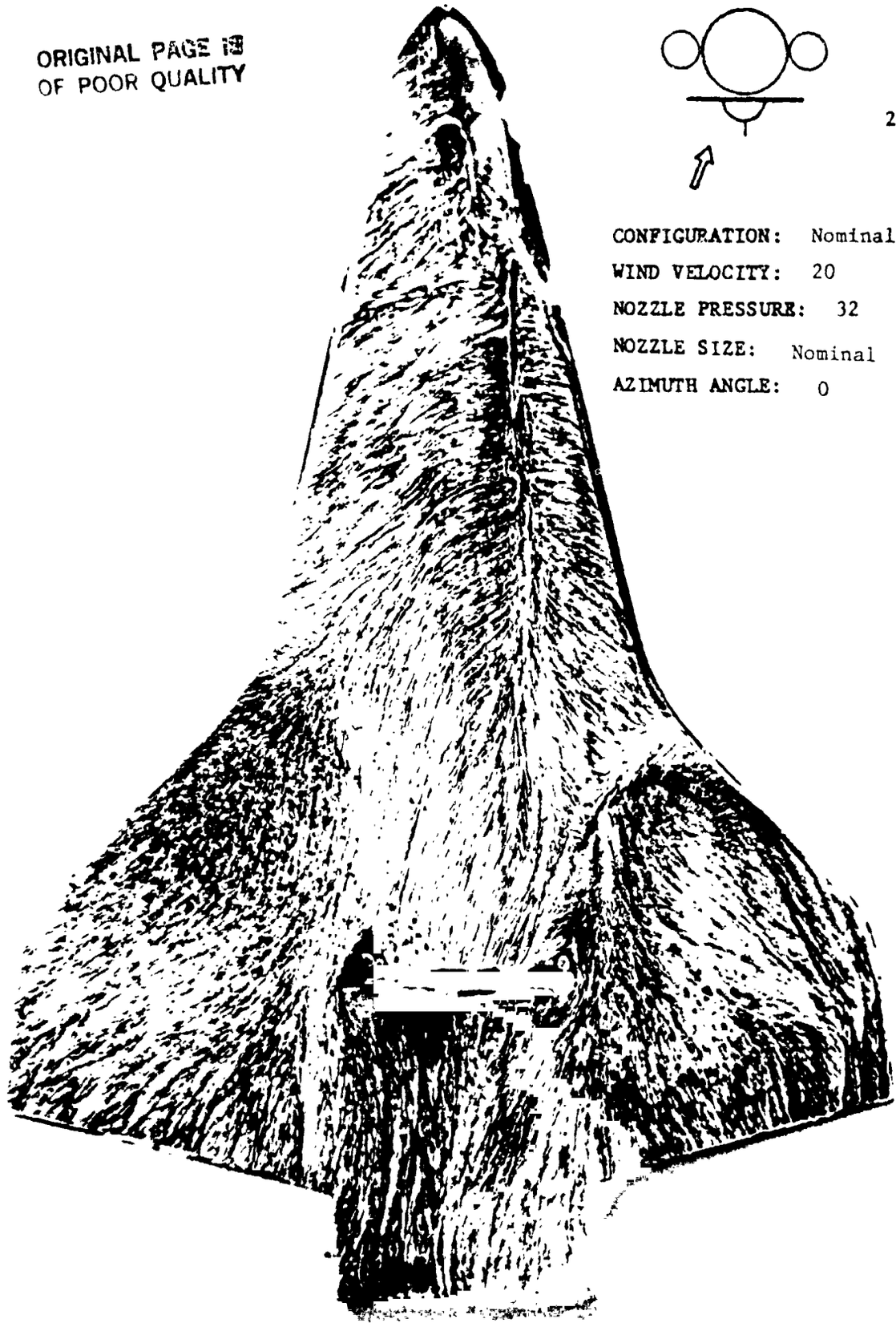
AZIMUTH ANGLE: 0

RUN NO. 2



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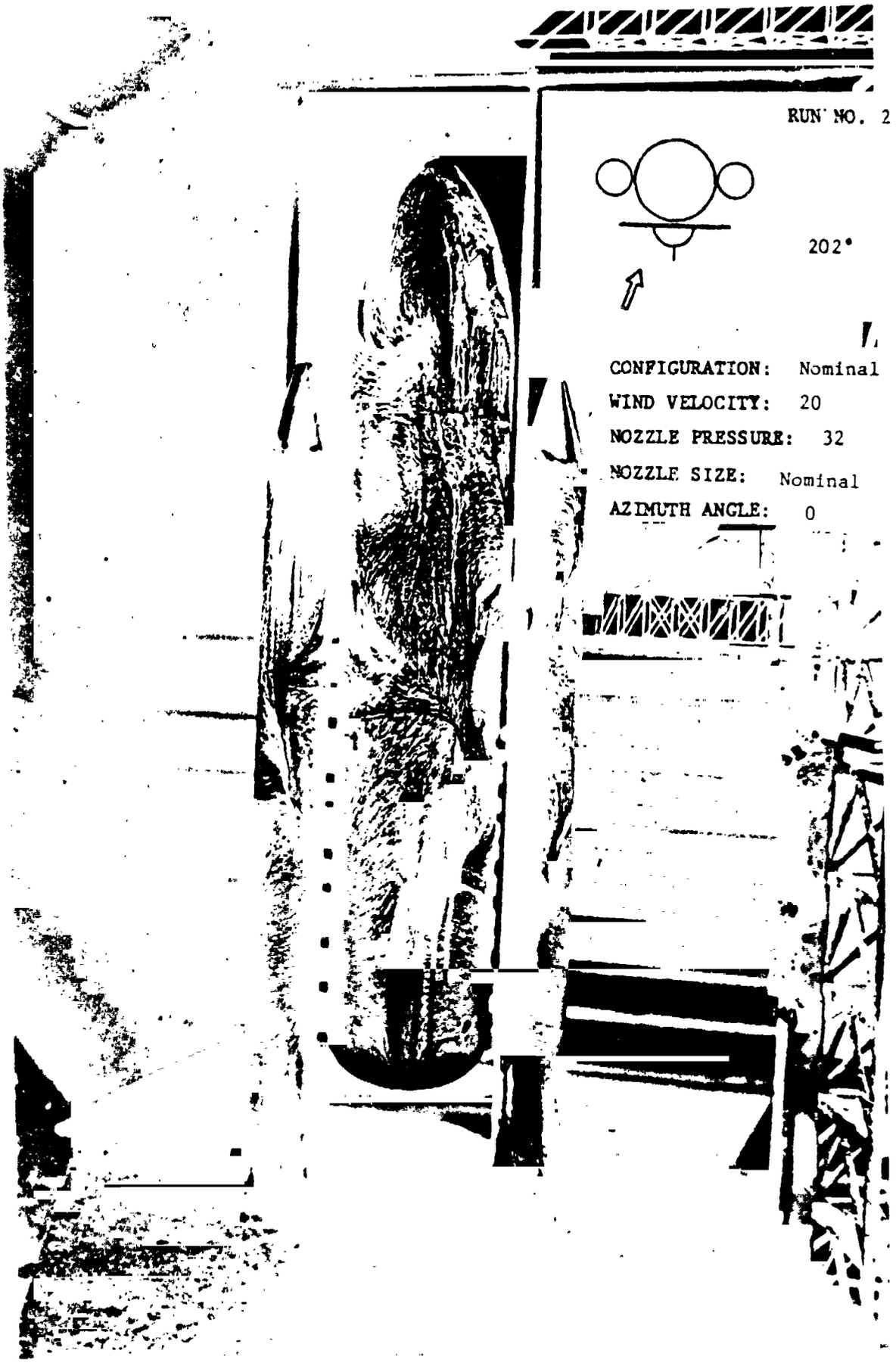
WIND VELOCITY: 20
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0



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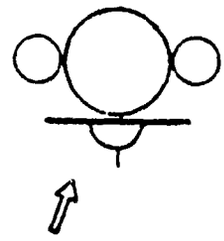


202°

CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

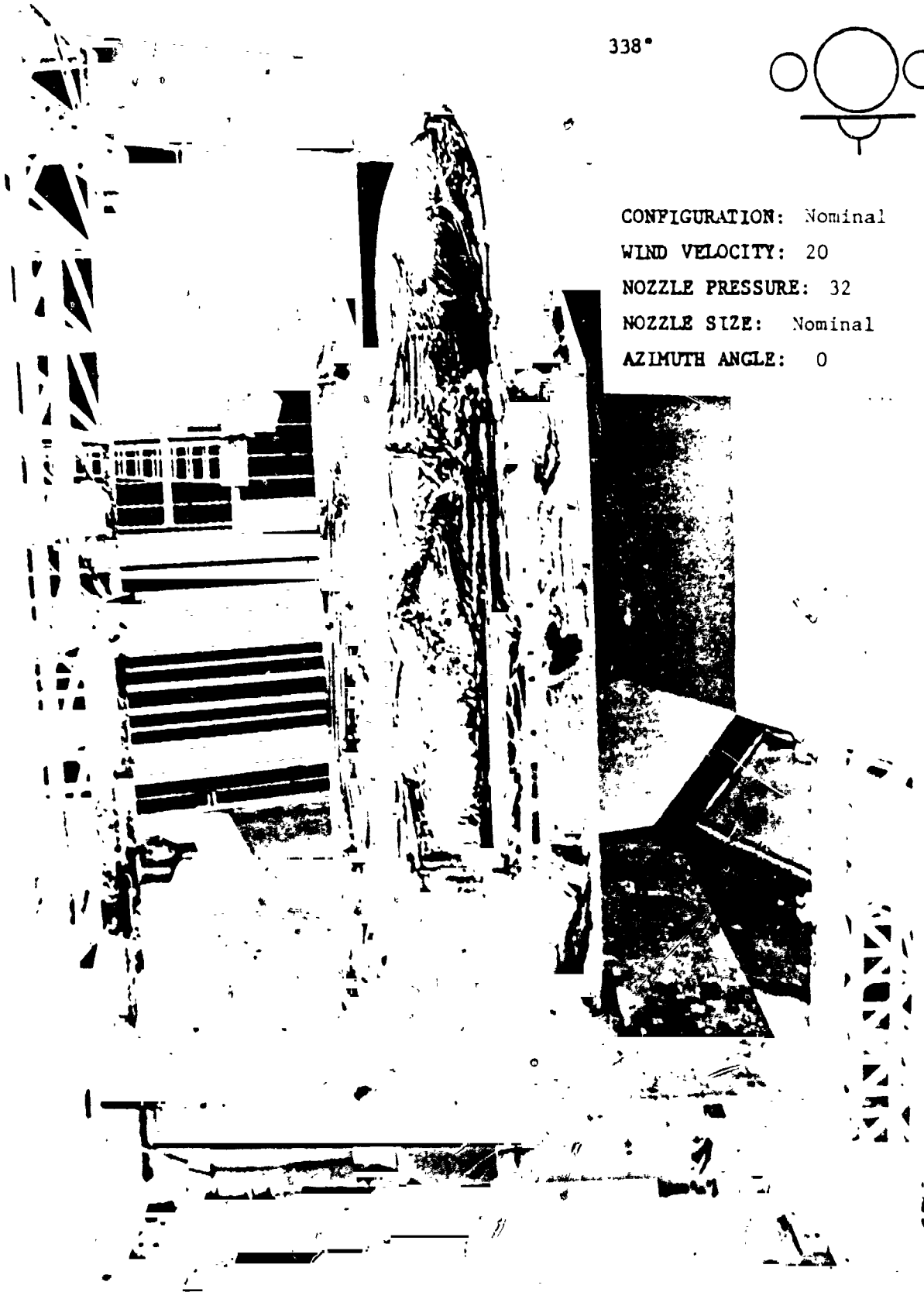
RUN
NO. 3

338°

CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN
NO. 3

338°



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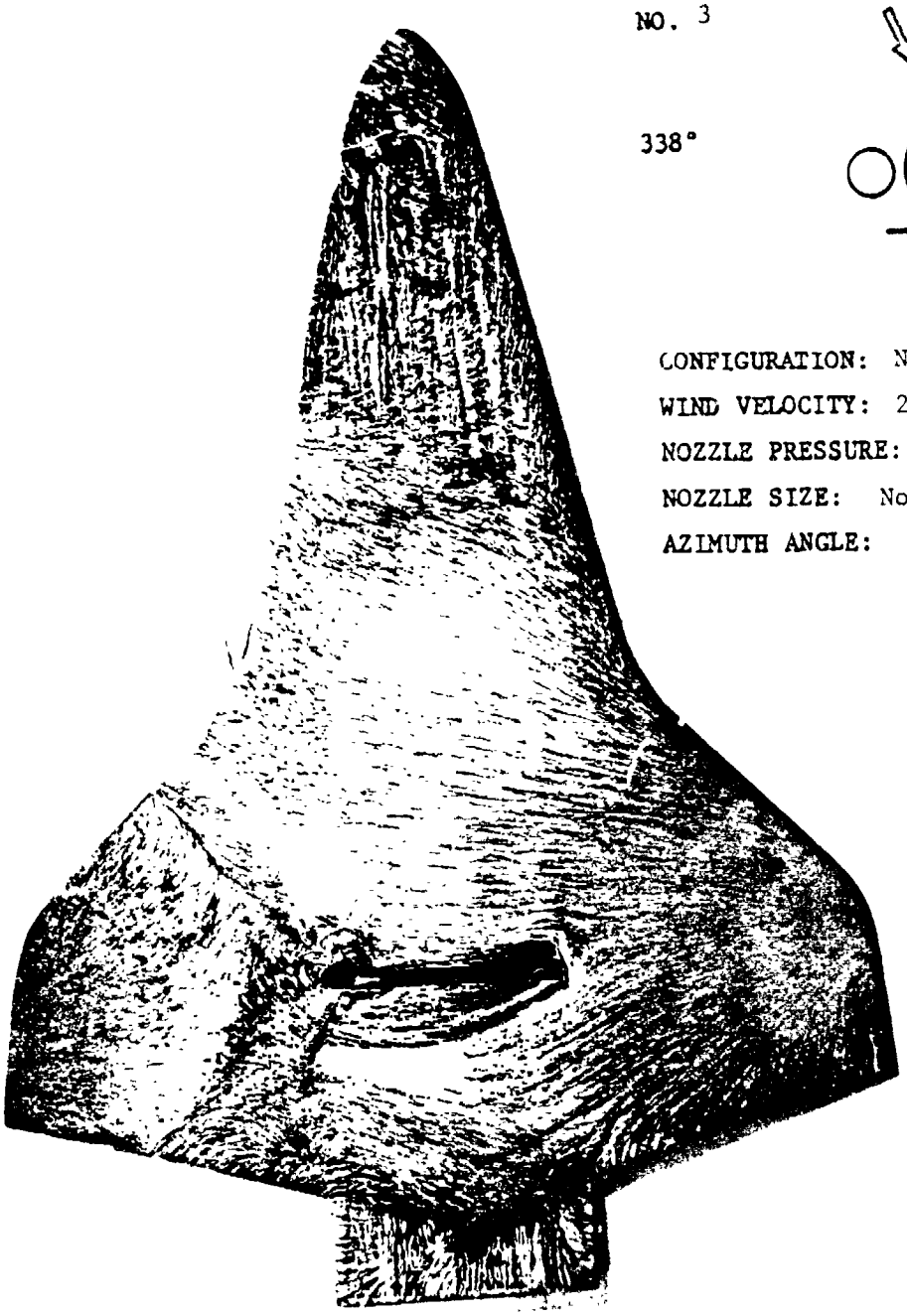
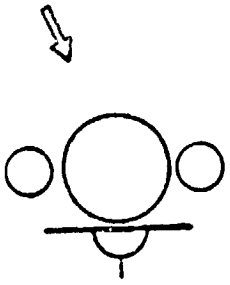
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN
NO. 3

338°





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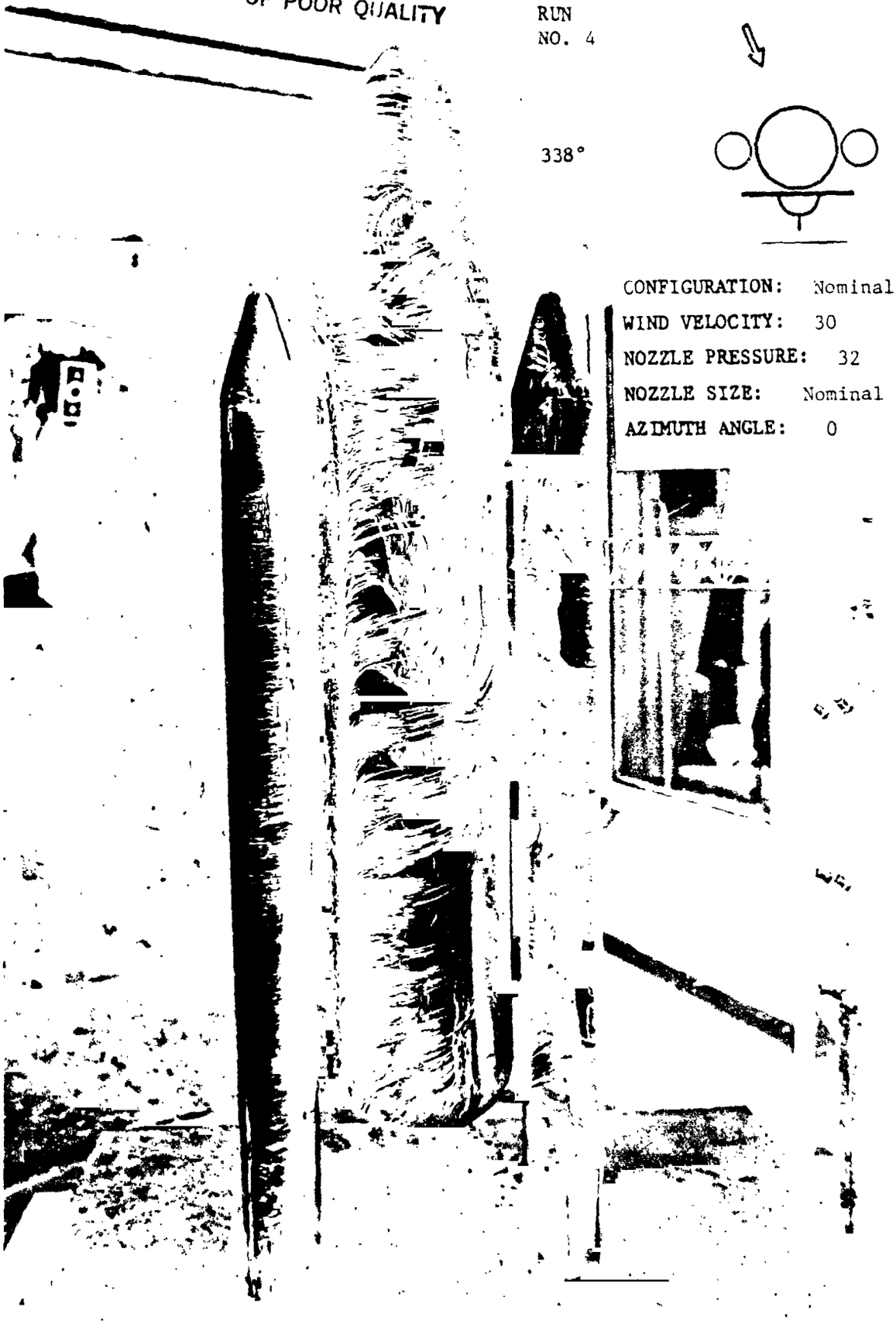
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN
NO. 4

338°



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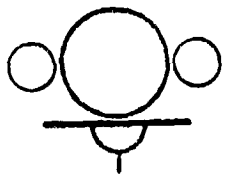
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN
NO. 4

338°



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NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
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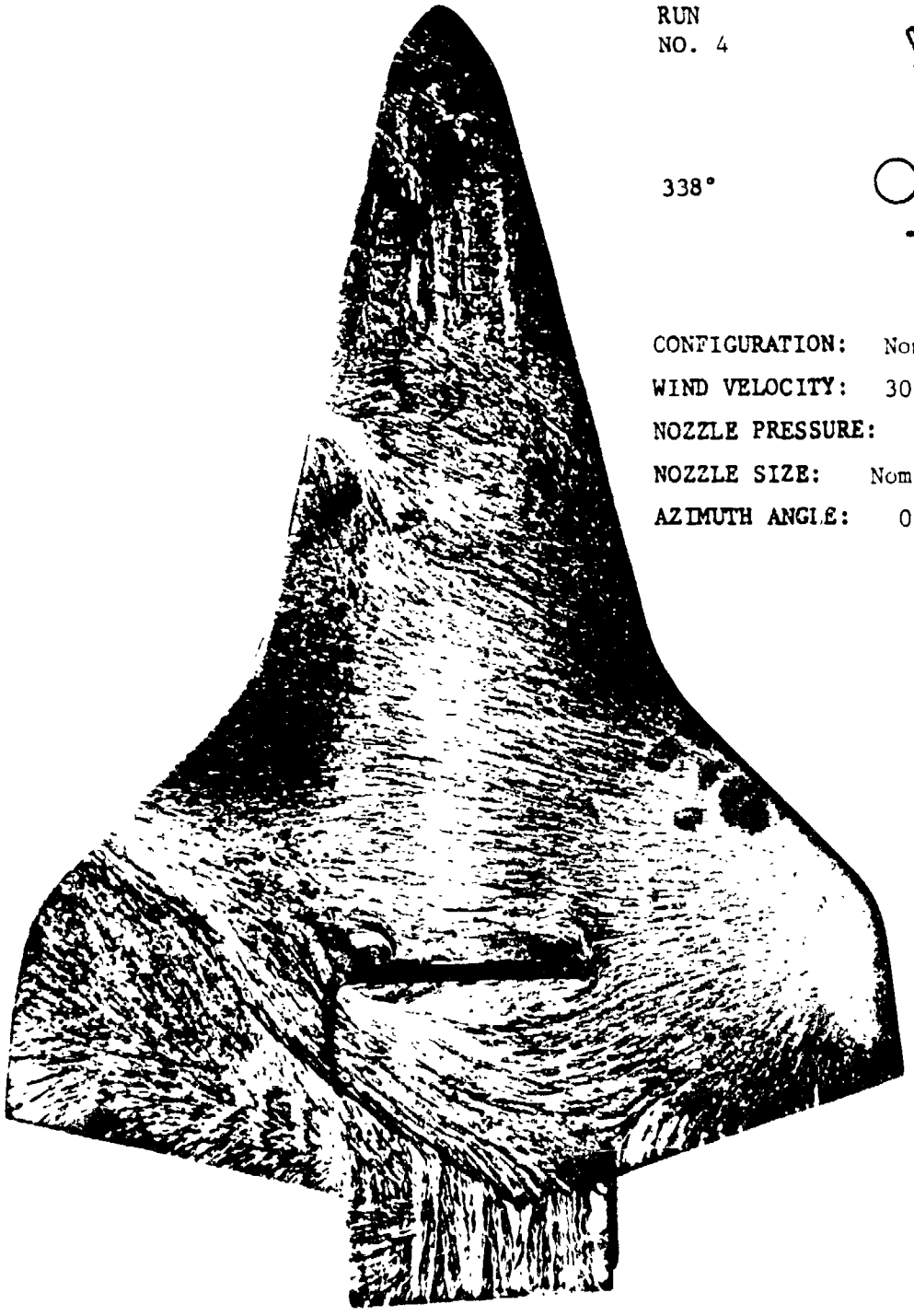
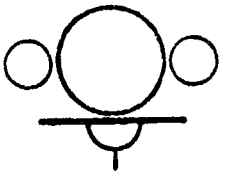


RUN
NO. 4

338°



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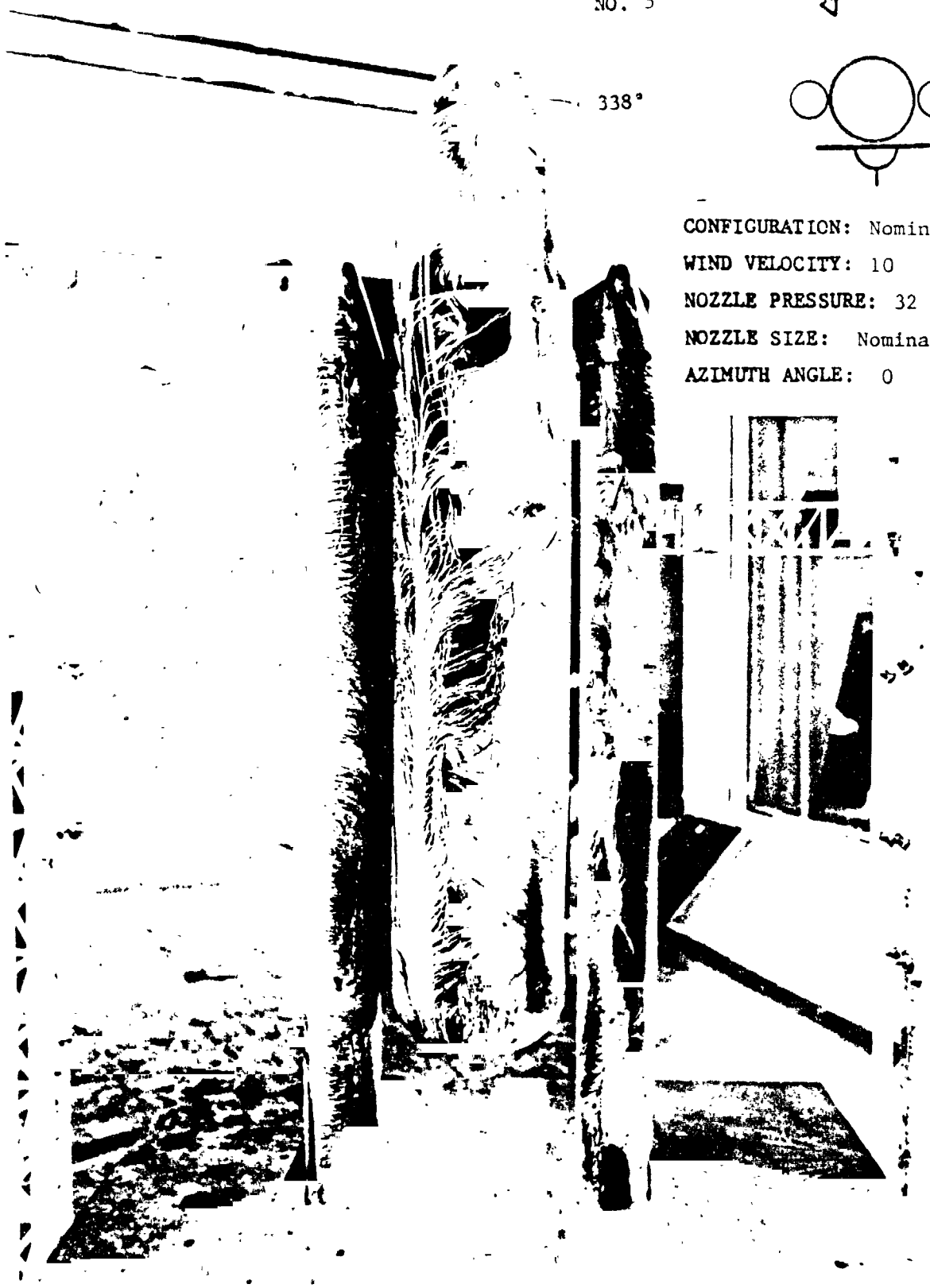
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN
NO. 5

338°



CONFIGURATION: Nominal
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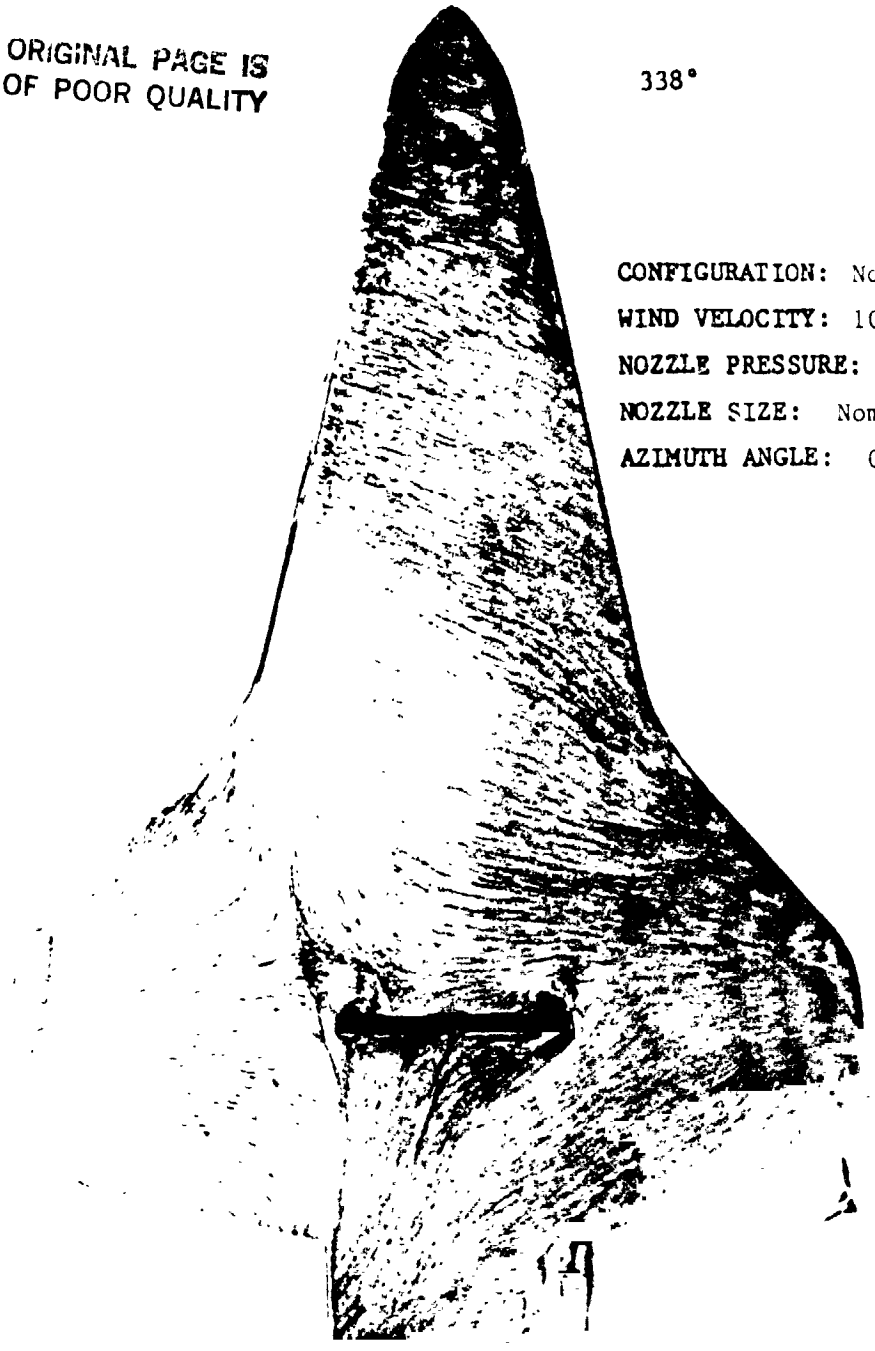
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN
NO. 5

338°



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WIND VELOCITY: 10
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

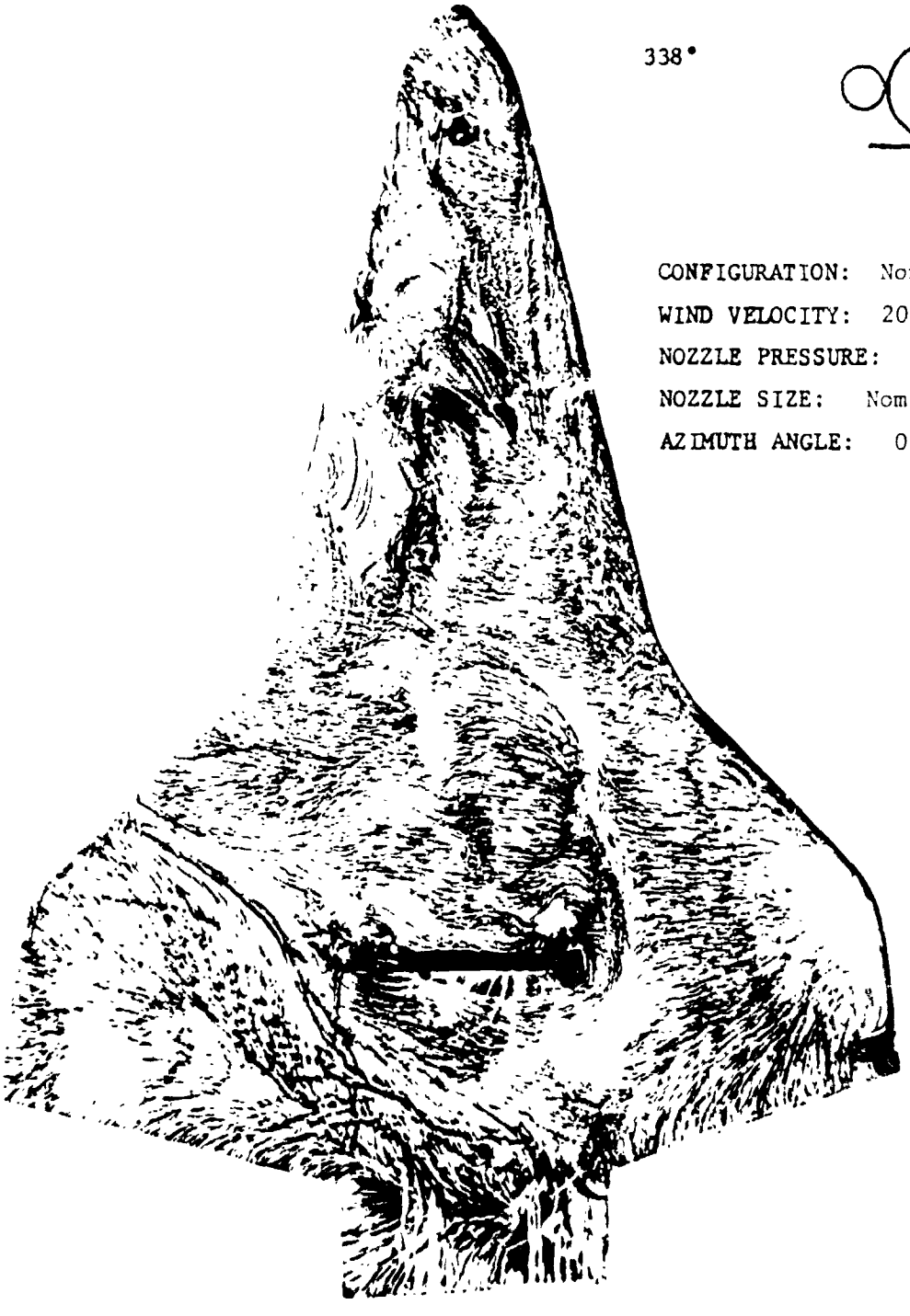
RUN NO. 5

338°

CONFIGURATION: Nominal
WIND VELOCITY: 10
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN
NO. 6

338°



CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 20
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN
NO. 6

338°

CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 20
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

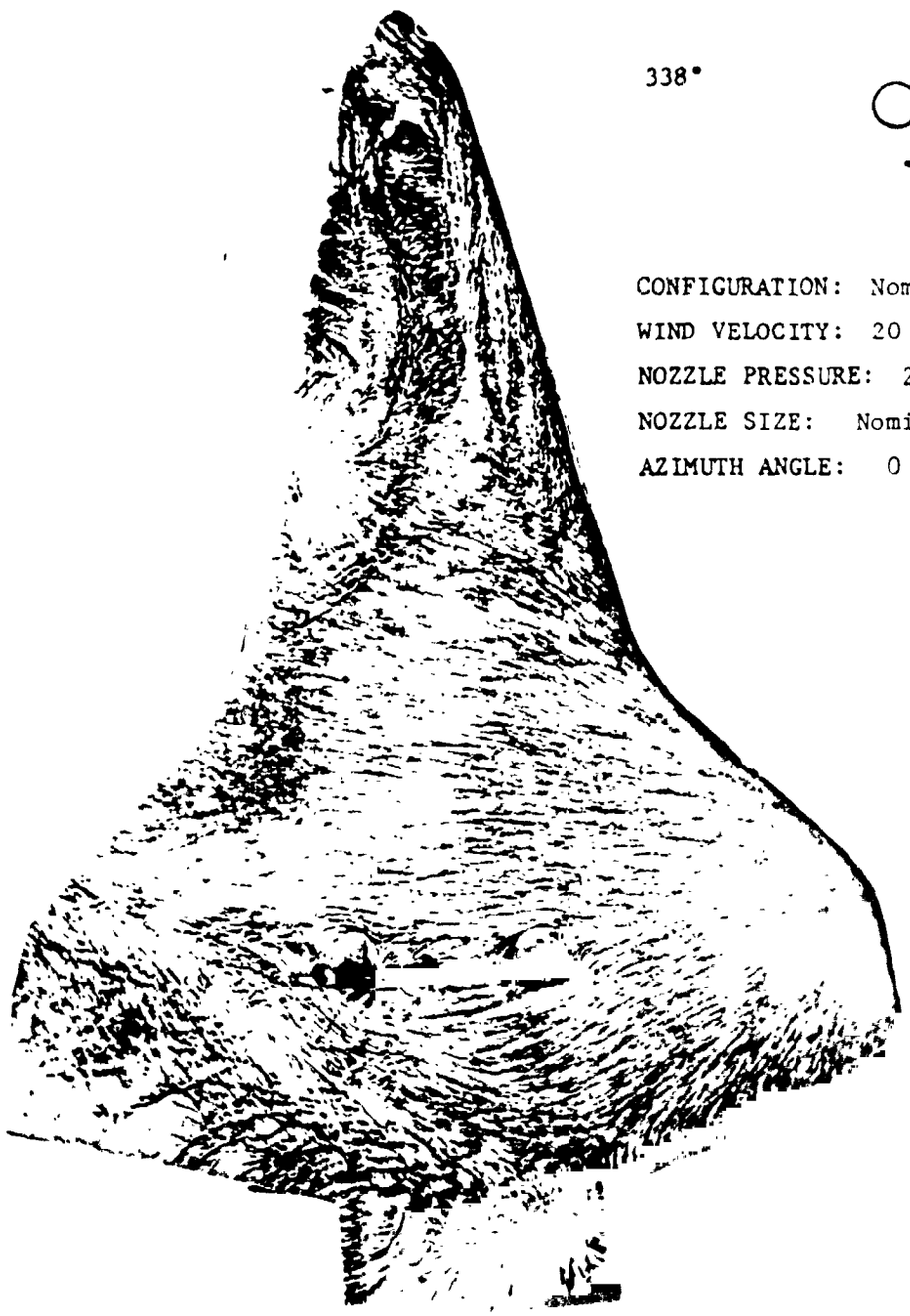
RUN
NO. 6

338°

CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 20
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN
NO. 7

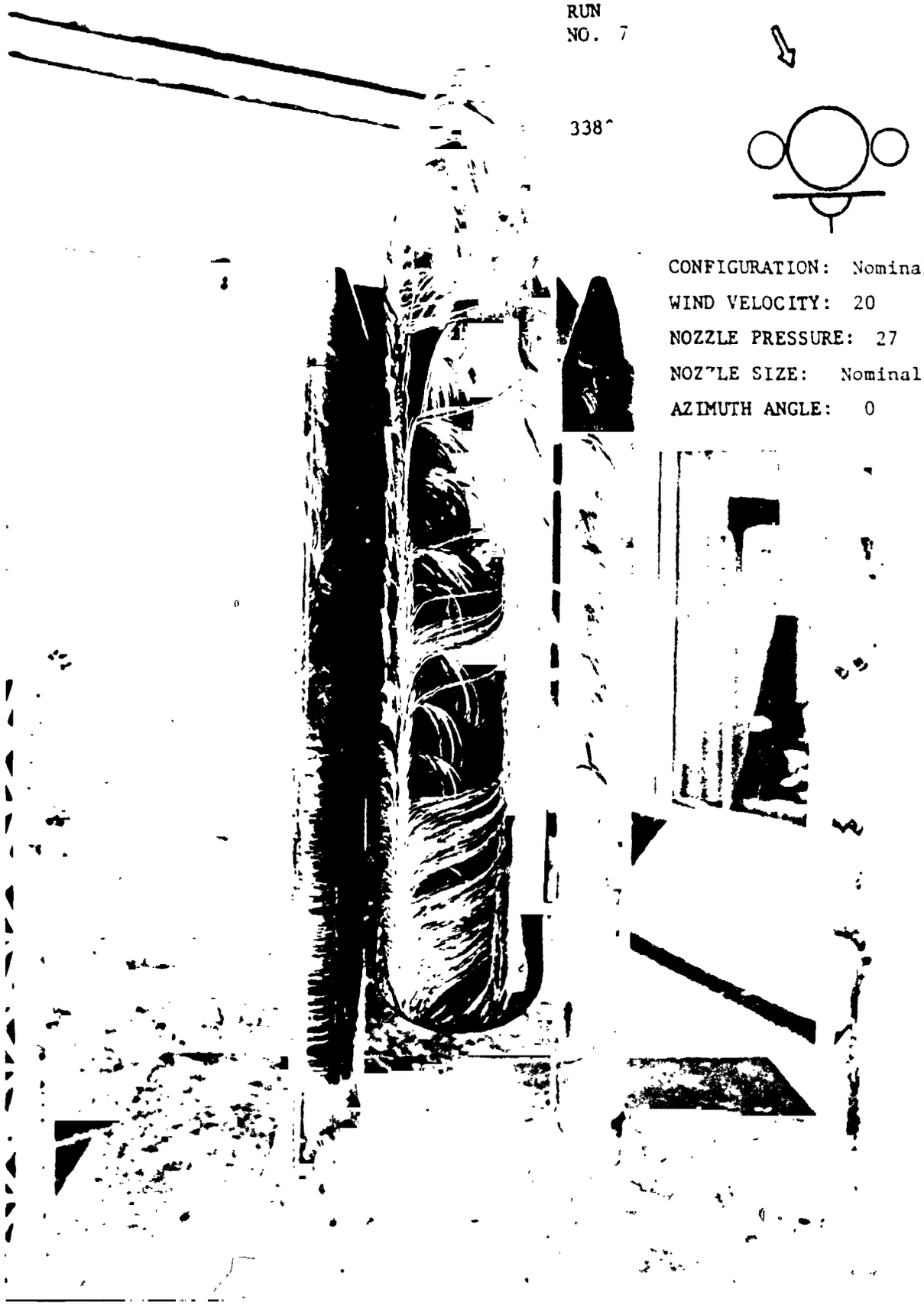
338°



CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 27
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN
NO. 7

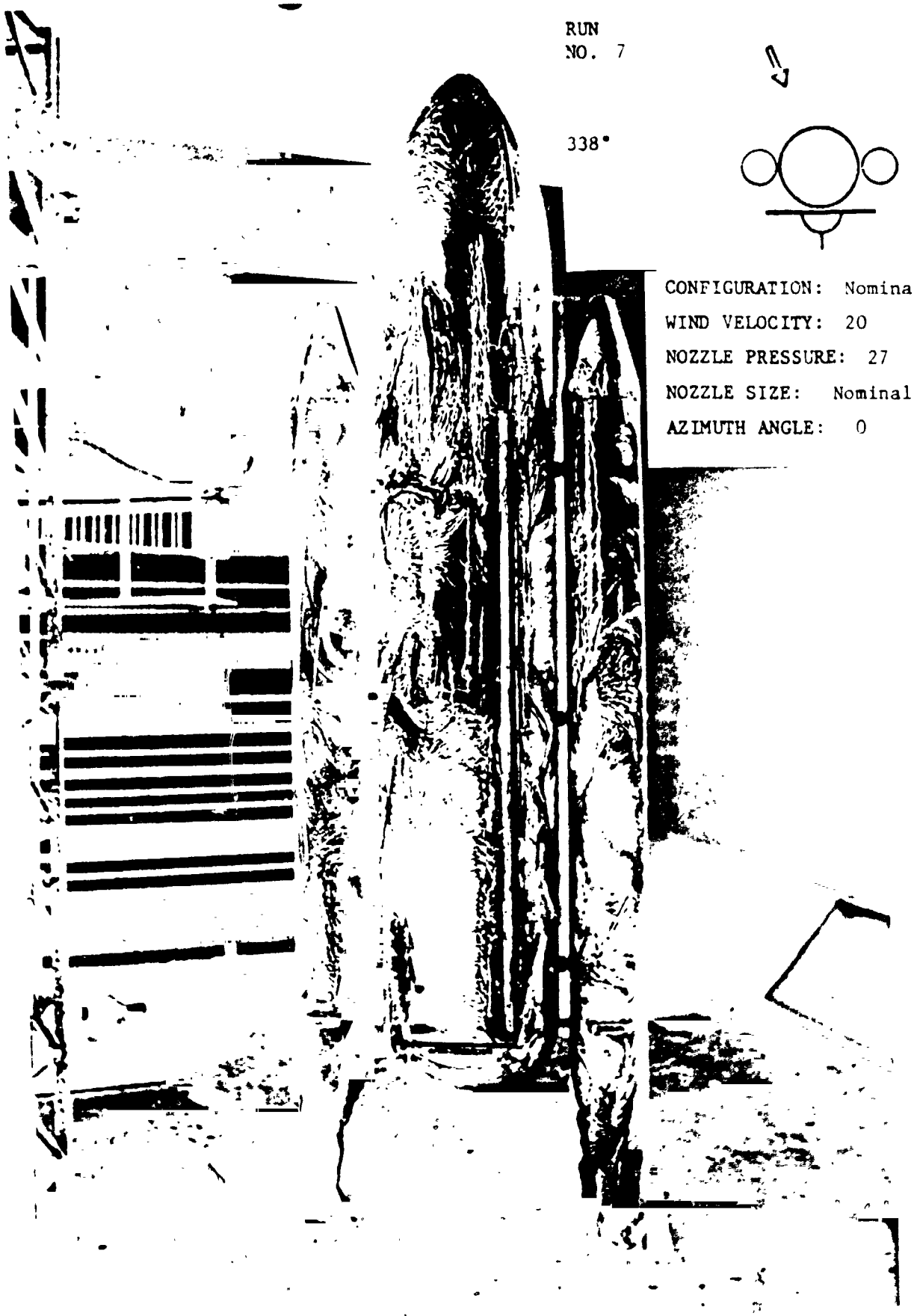
338°



CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 27
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN
NO. 7

338°



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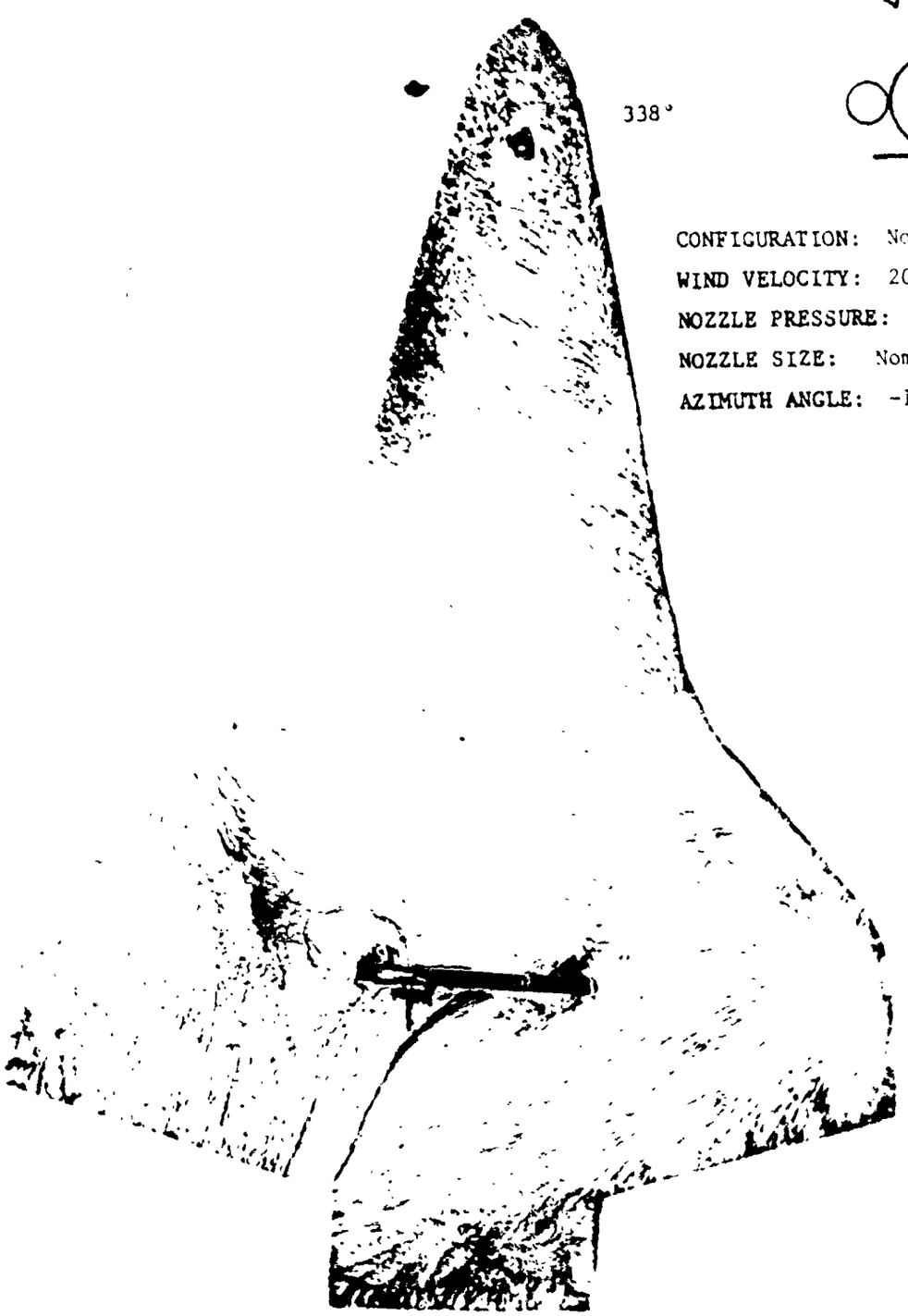
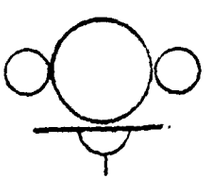
WIND VELOCITY: 20
NOZZLE PRESSURE: 27
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN
NO. 8



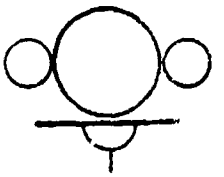
338°



CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: -15

RUN
NO. 8

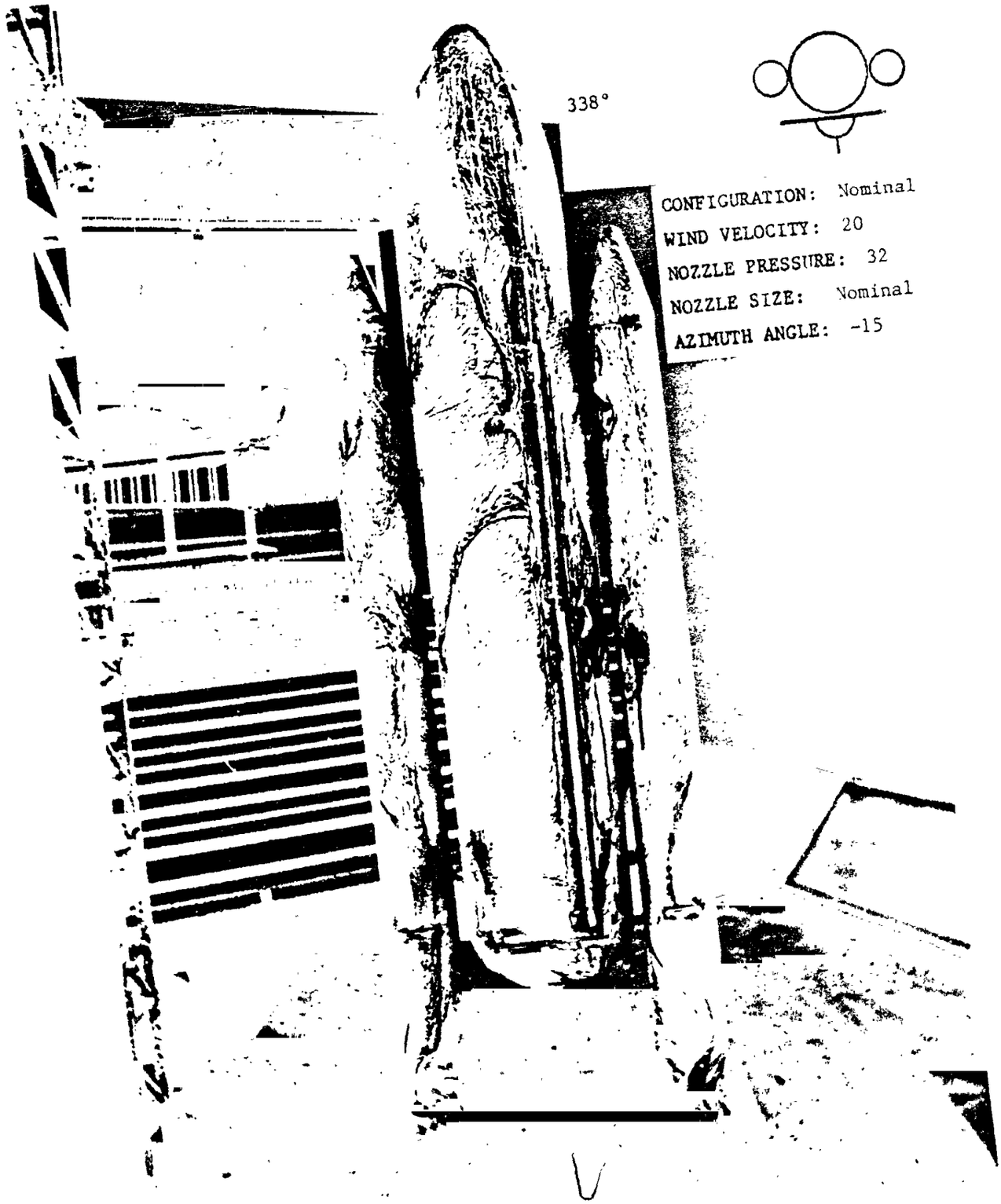
338°



CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: -15

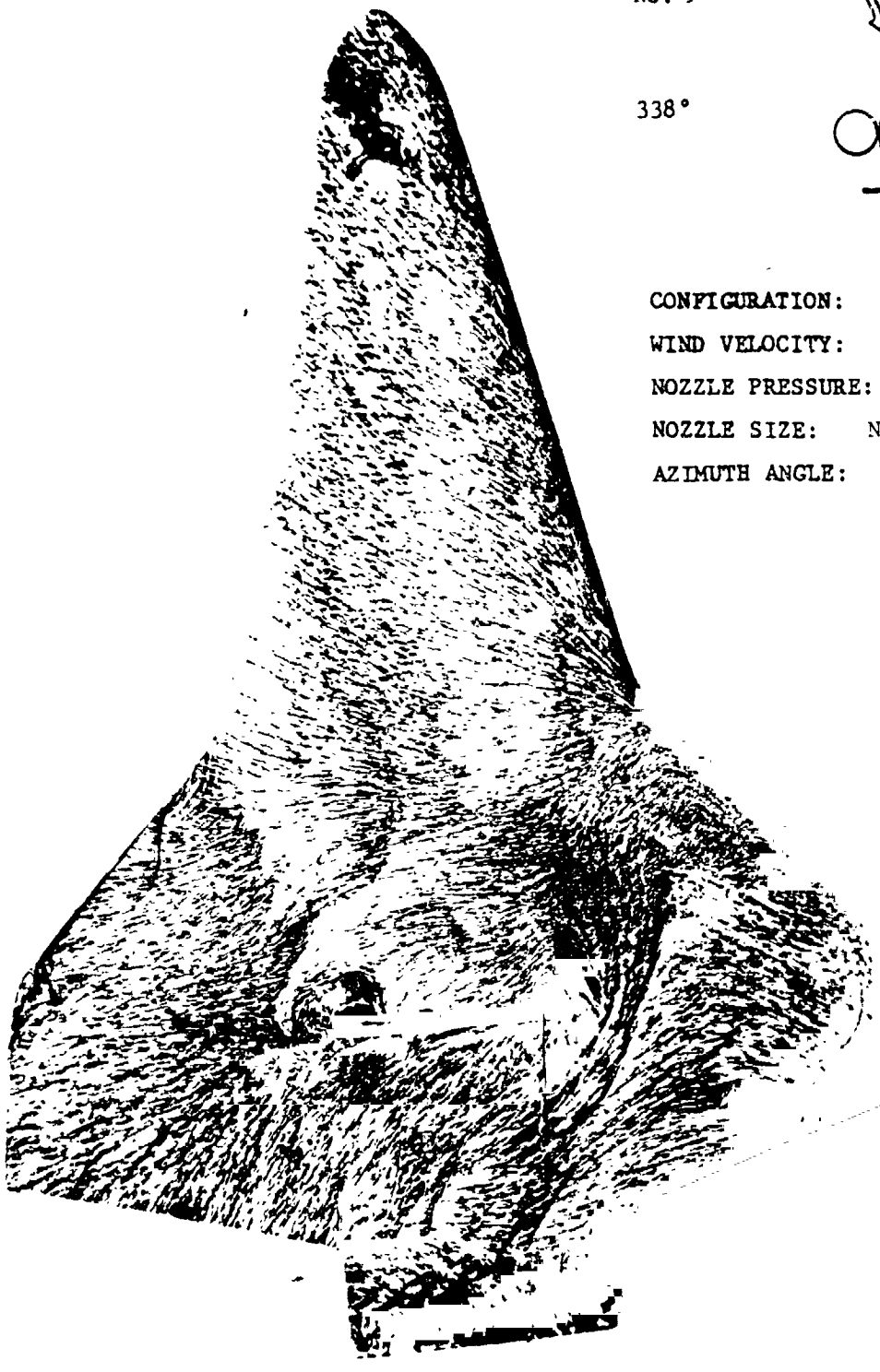
RUN
NO. 8

338°

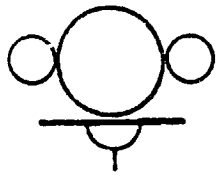


CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: -15

RUN
NO. 9



338°



CONFIGURATION: Nominal

WIND VELOCITY: 20

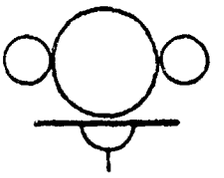
NOZZLE PRESSURE: 32

NOZZLE SIZE: Nominal

AZIMUTH ANGLE: -30

RUN
NO. 9

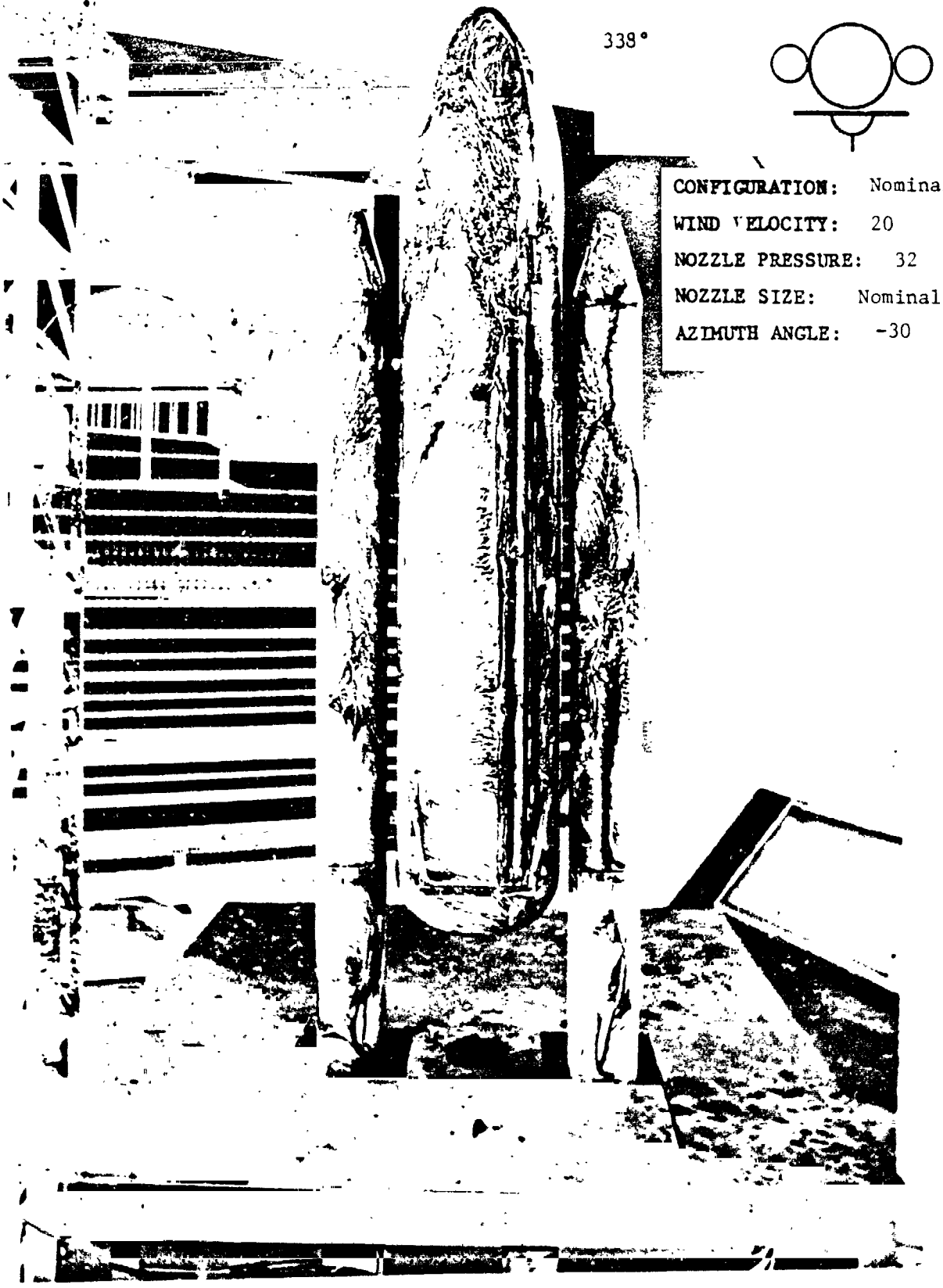
338°



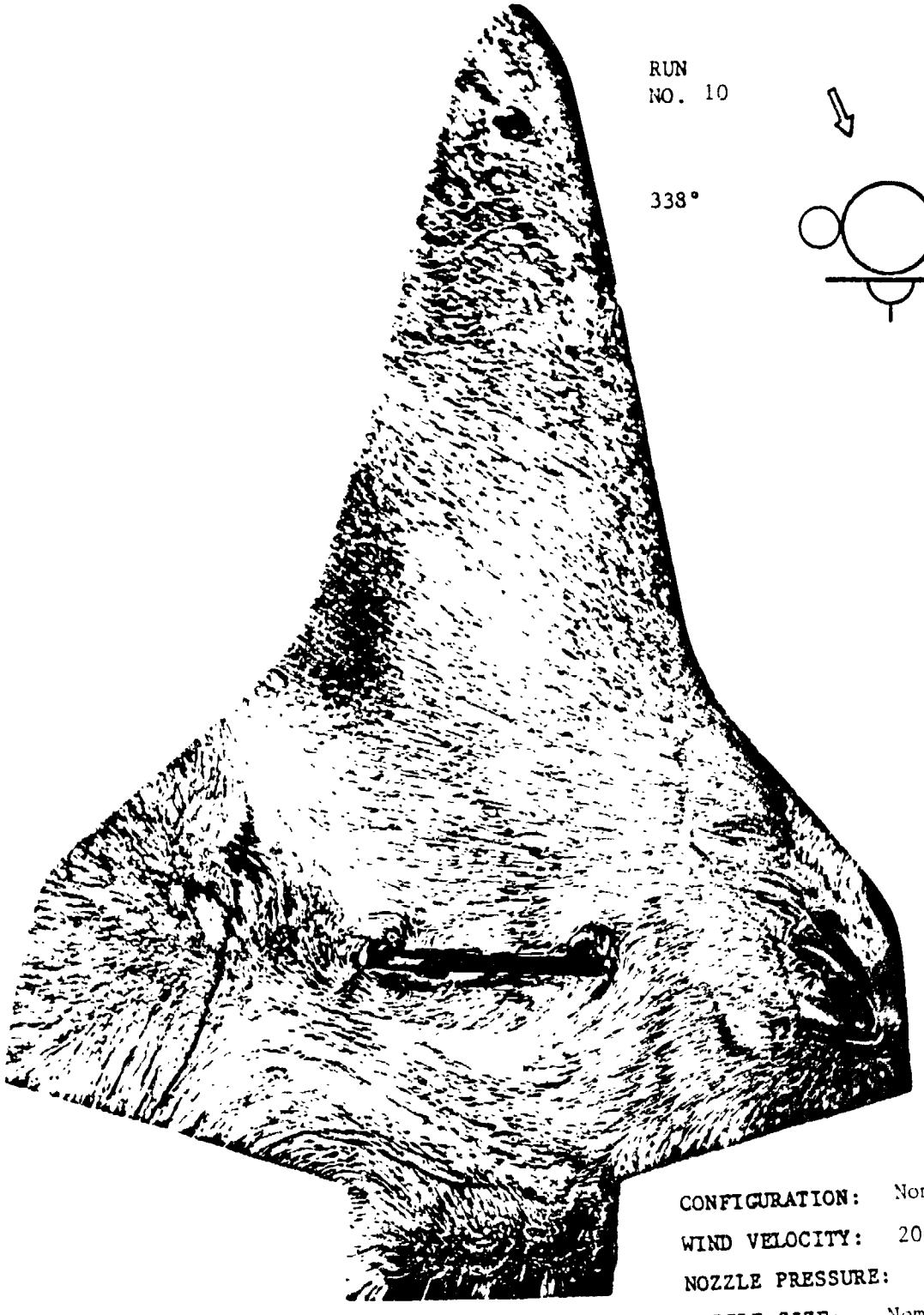
CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: -30

RUN
NO. 9

338°



CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: -30



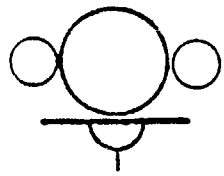
RUN
NO. 10

338°

CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: -30

RUN
NO. 10

338°



CONFIGURATION: Nominal
WIND VELOCITY: 30
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: -30

RUN
NO. 11

338°

CONFIGURATION: Nominal
WIND VELOCITY: 30
NOZZLE PRESSURE: 27
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: -30

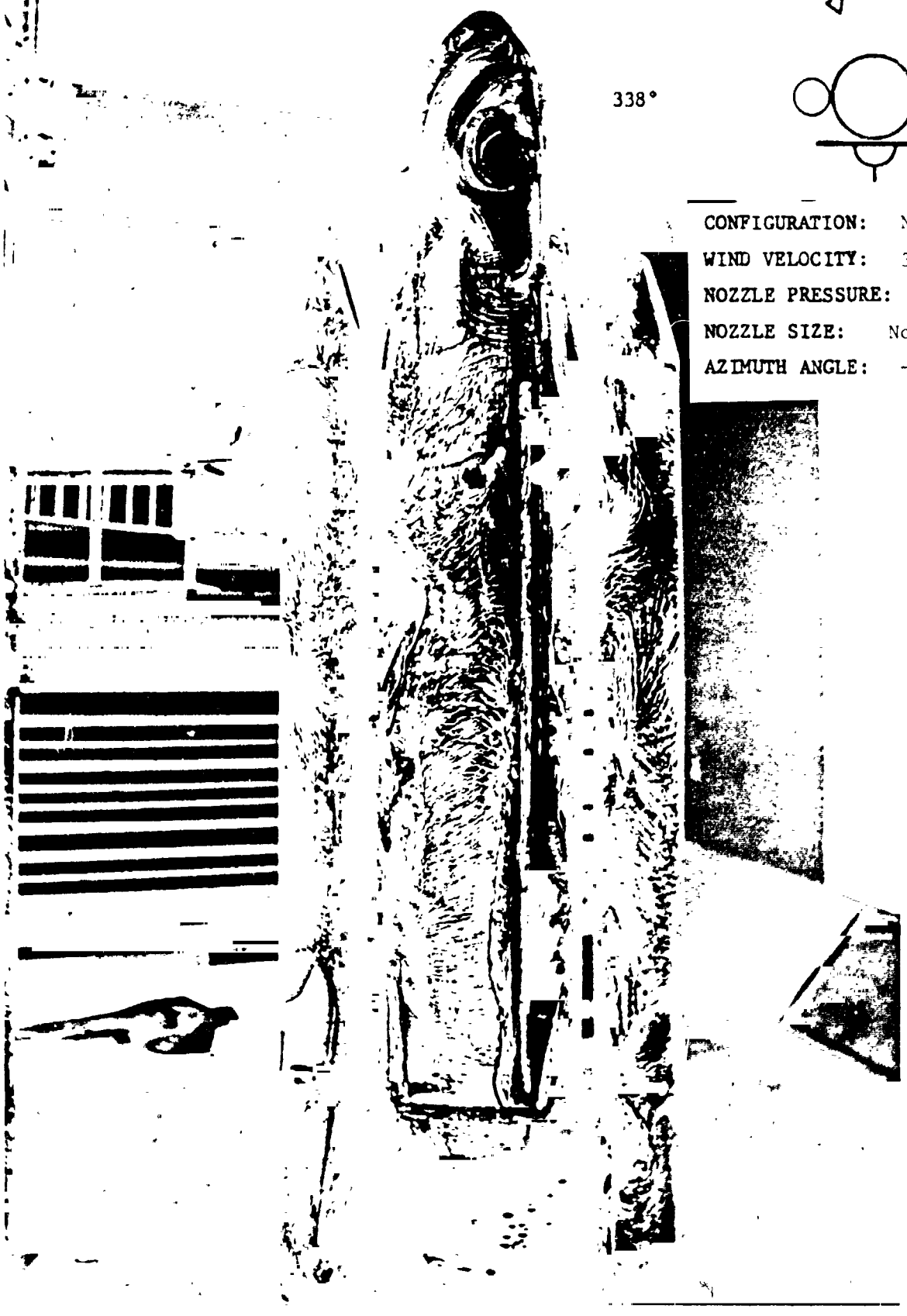
RUN
NO. 11

338°

CONFIGURATION: Nominal
WIND VELOCITY: 30
NOZZLE PRESSURE: 27
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: -30

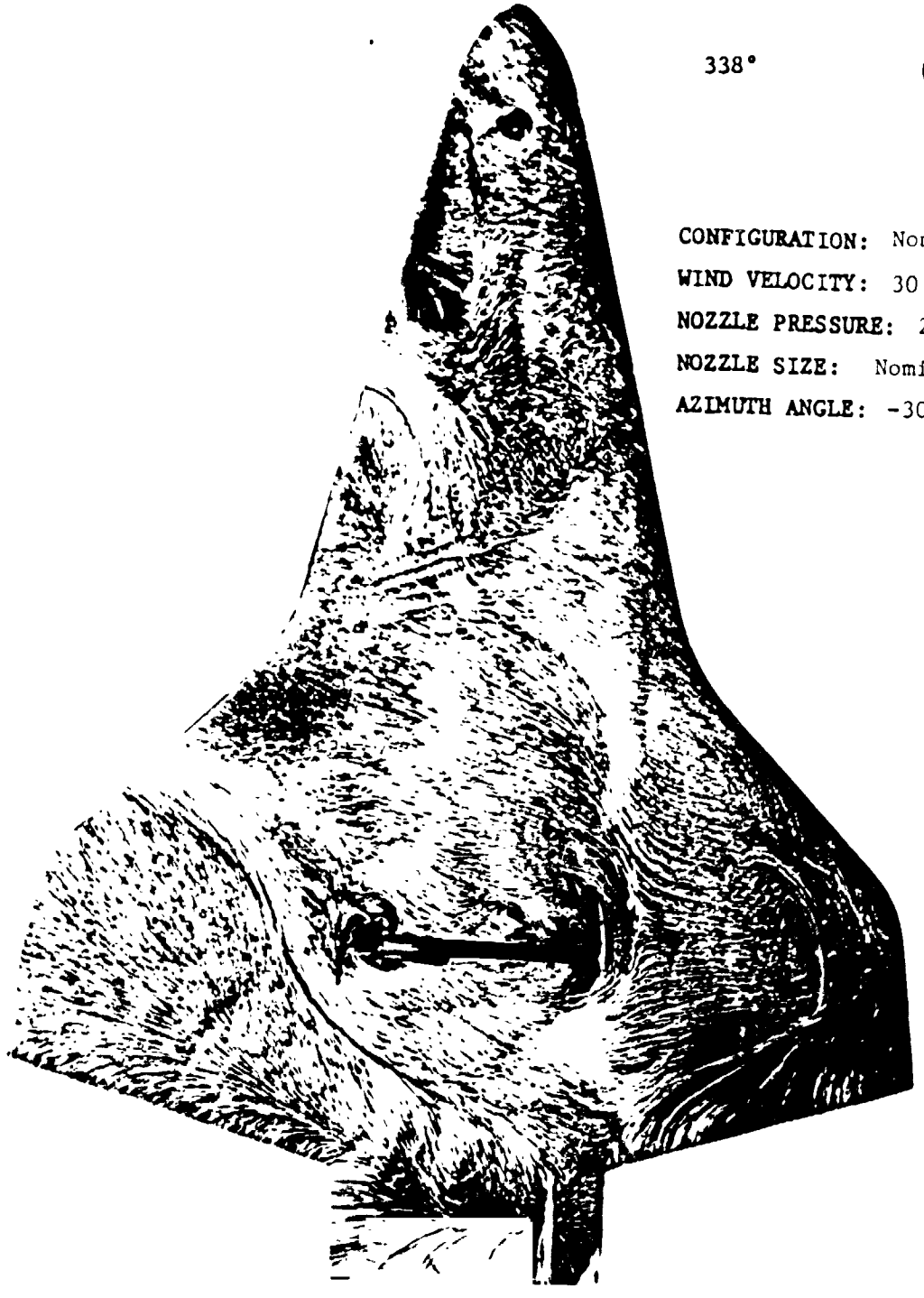
RUN
NO. 11

338°

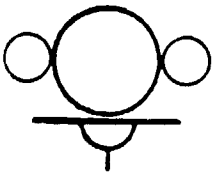


CONFIGURATION: Nominal
WIND VELOCITY: 30
NOZZLE PRESSURE: 27
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: -30

RUN
NO. 12



338°



CONFIGURATION: Nominal
WIND VELOCITY: 30
NOZZLE PRESSURE: 20
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: -30

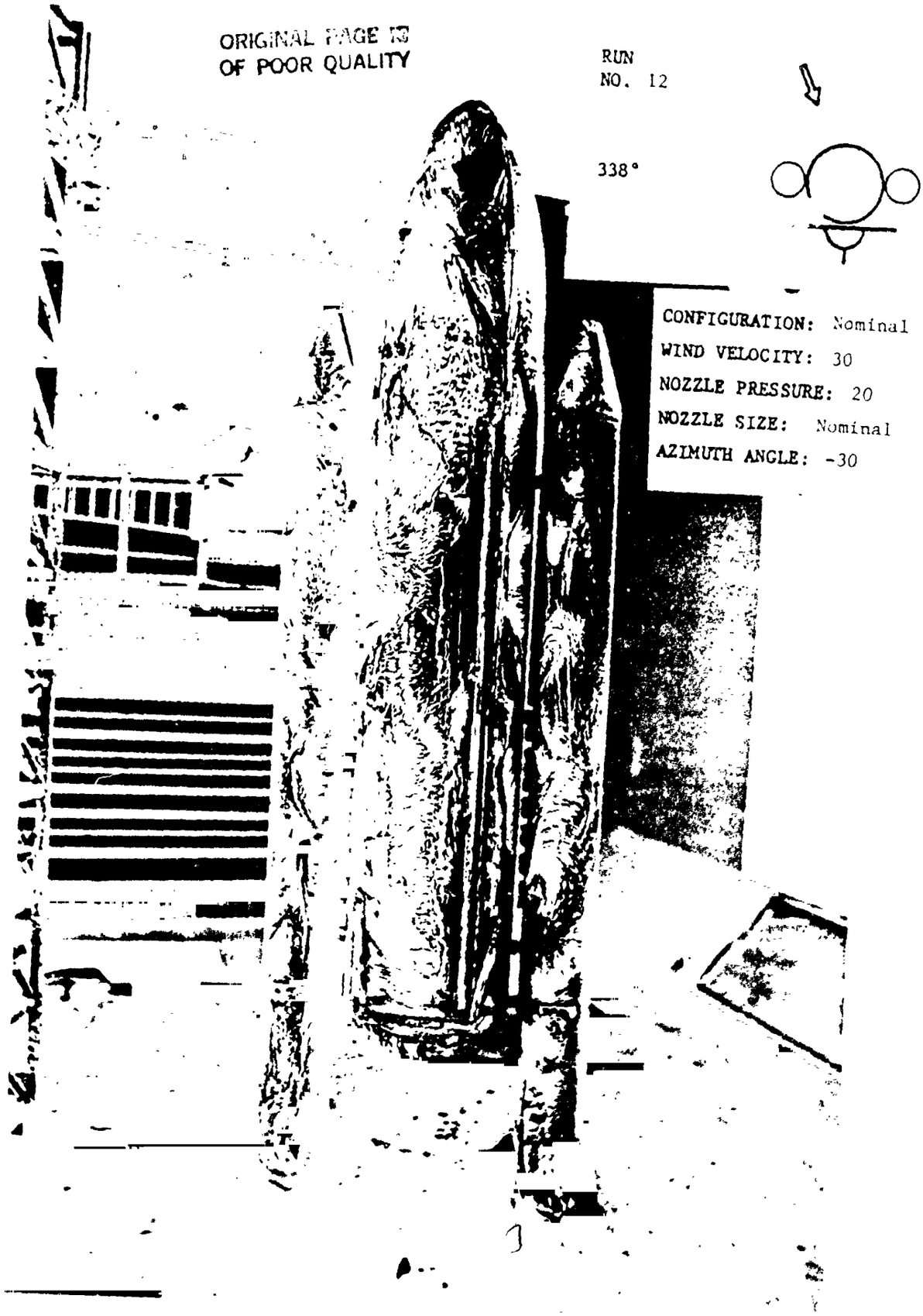
RUN
NO. 12

338°

CONFIGURATION: Nominal
WIND VELOCITY: 30
NOZZLE PRESSURE: 20
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: -30

RUN
NO. 12

338°



CONFIGURATION: Nominal
WIND VELOCITY: 30
NOZZLE PRESSURE: 20
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: -30

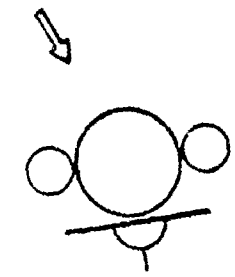
RUN
NO. 13

338°

CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 0
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: /

RUN
NO. 13

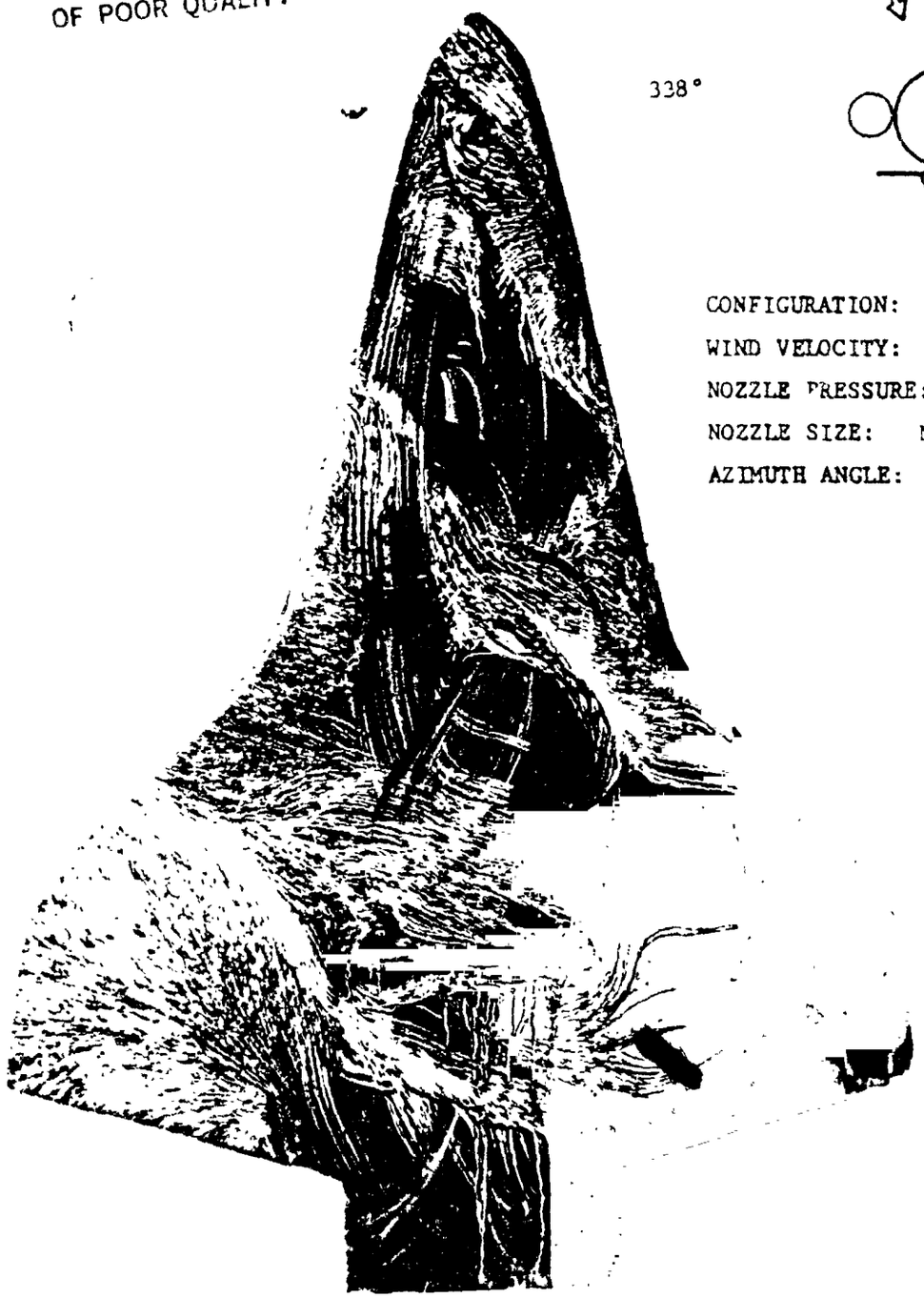
338°



CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 0
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: /

RUN
NO. 13

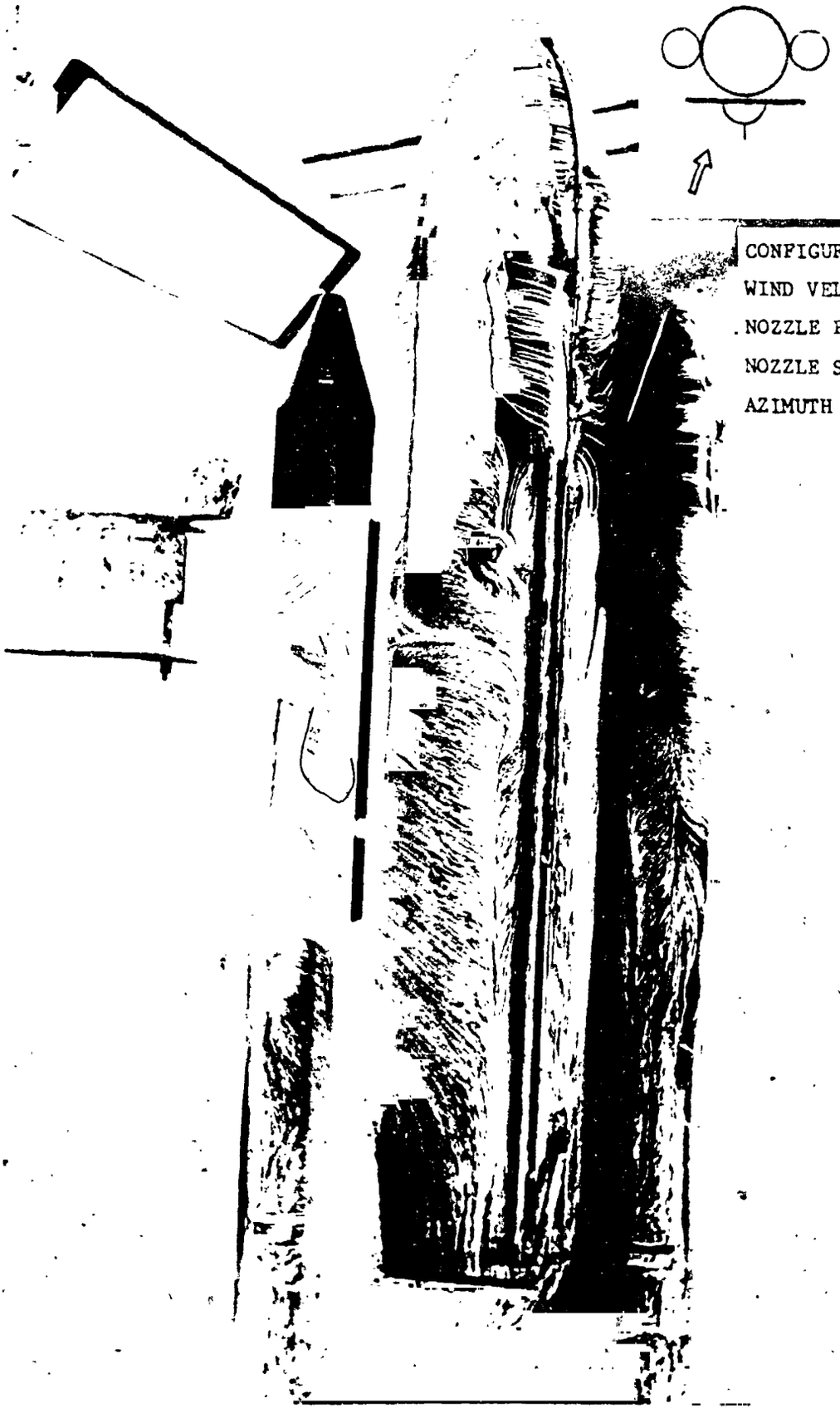
338°



CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 0
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: /

RUN NO 14

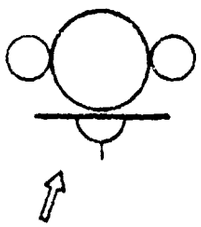
RUN NO. 14



202°

CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 0
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: /

RUN NO. 14



202°

CONFIGURATION: Nominal

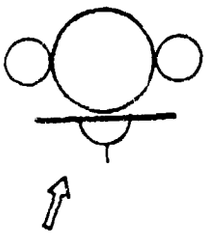
WIND VELOCITY: 20

NOZZLE PRESSURE: 0

NOZZLE SIZE: Nominal

AZIMUTH ANGLE: /

RUN NO. 15



202°

CONFIGURATION: Nominal

WIND VELOCITY: 30

NOZZLE PRESSURE: 32

NOZZLE SIZE: Nominal

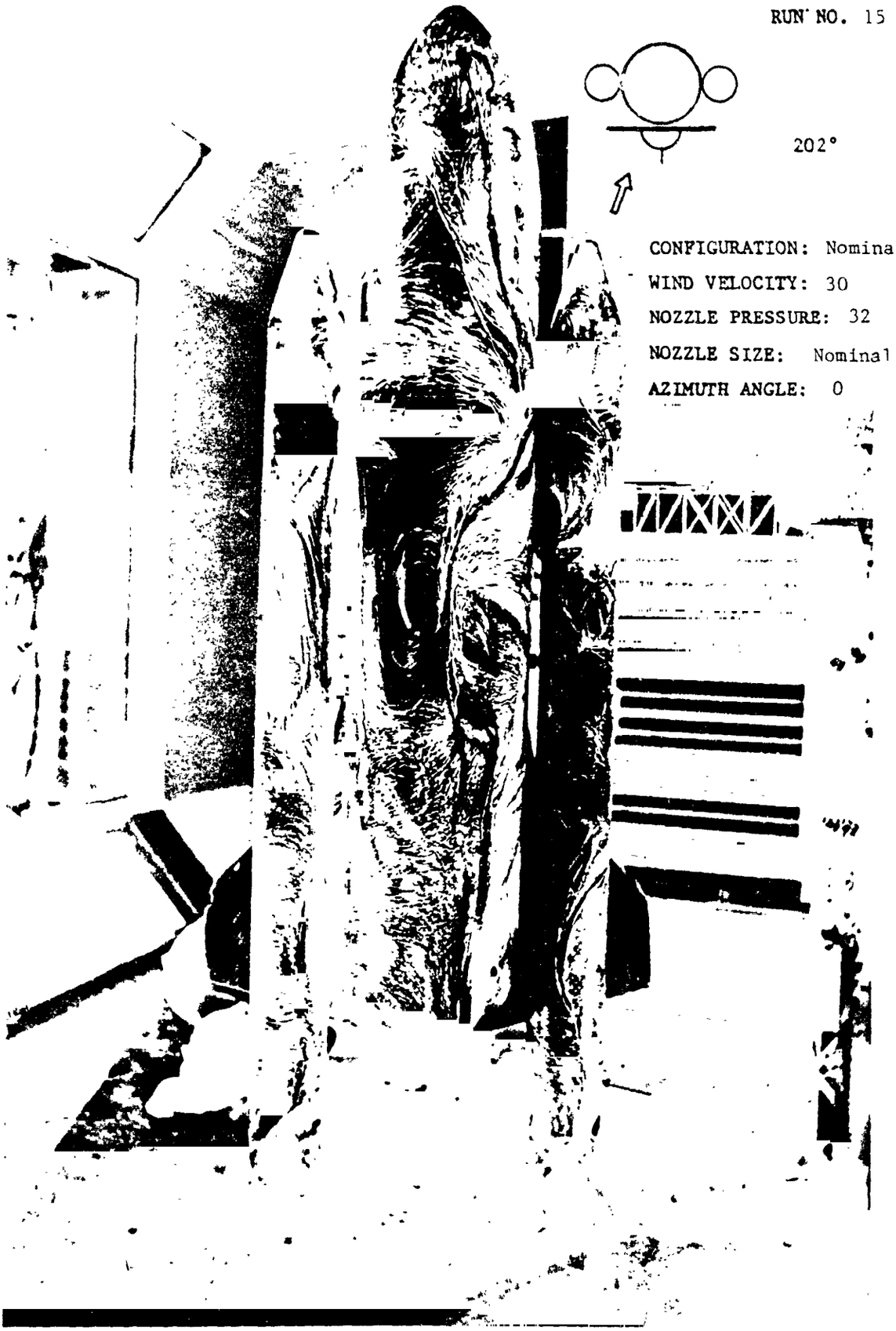
AZIMUTH ANGLE: 0

RUN NO. 15

202°

CONFIGURATION: Nominal
WIND VELOCITY: 30
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

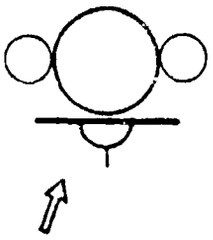
RUN NO. 15



202°

CONFIGURATION: Nominal
WIND VELOCITY: 30
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN NO. 16



202°

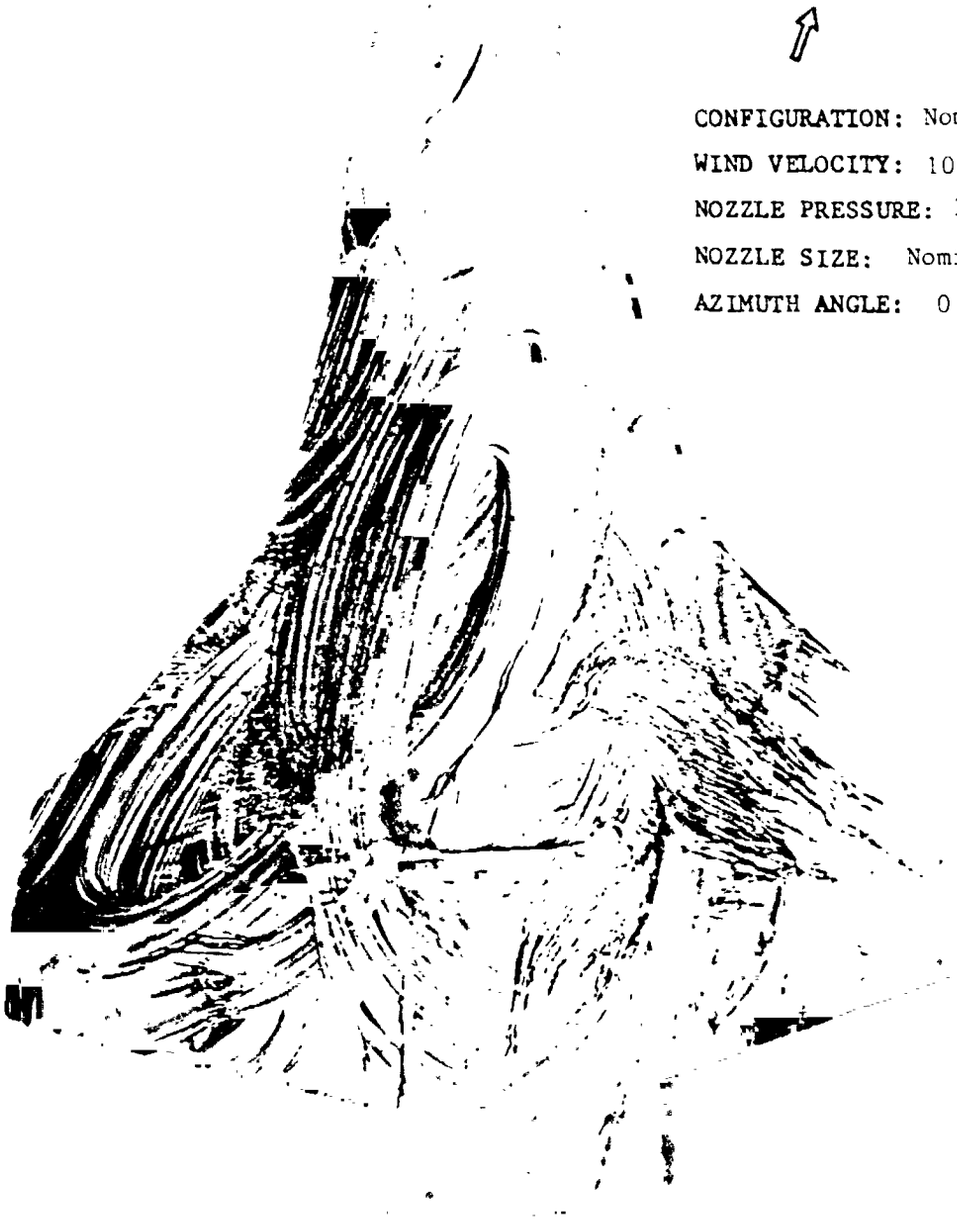
CONFIGURATION: Nominal

WIND VELOCITY: 10

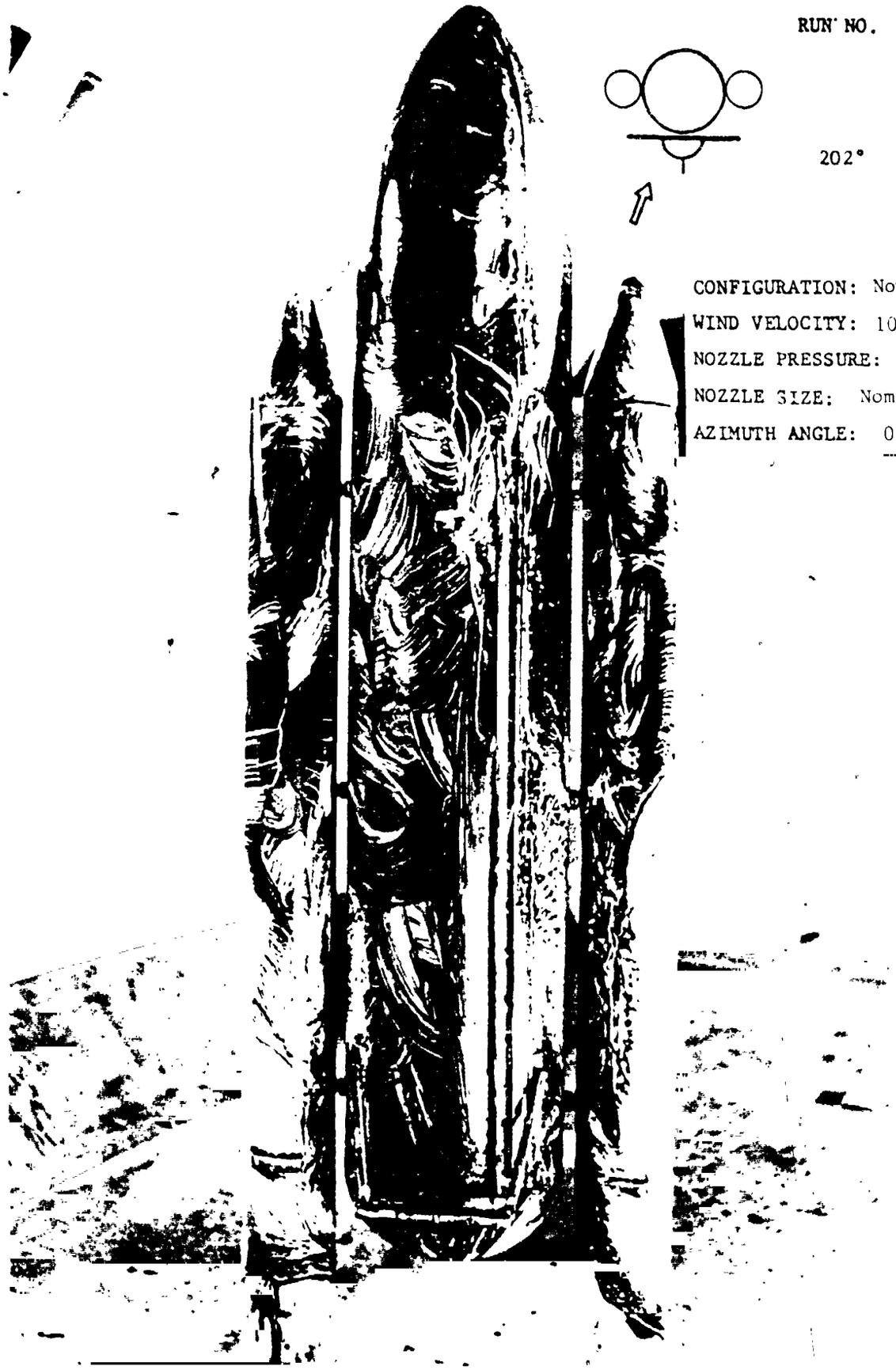
NOZZLE PRESSURE: 32

NOZZLE SIZE: Nominal

AZIMUTH ANGLE: 0



RUN NO. 16



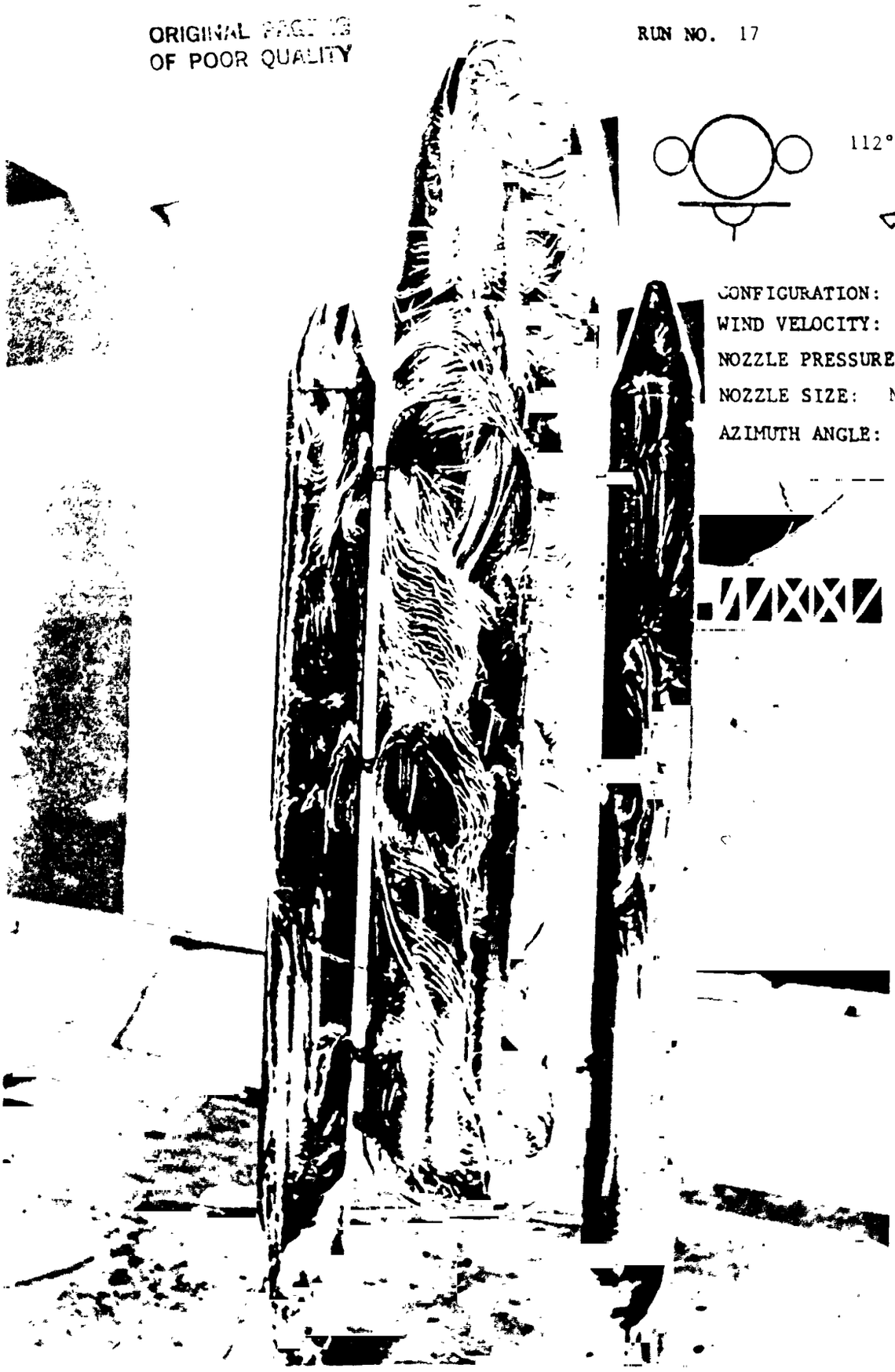
202°

CONFIGURATION: Nominal
WIND VELOCITY: 10
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN NO. 16

CONFIGURATION: Nominal
WIND VELOCITY: 10
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

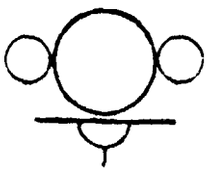
RUN NO. 17



112°

CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 0
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: /

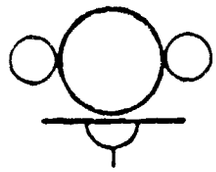
RUN NO. 17



112°

CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 0
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: /

RUN NO. 17



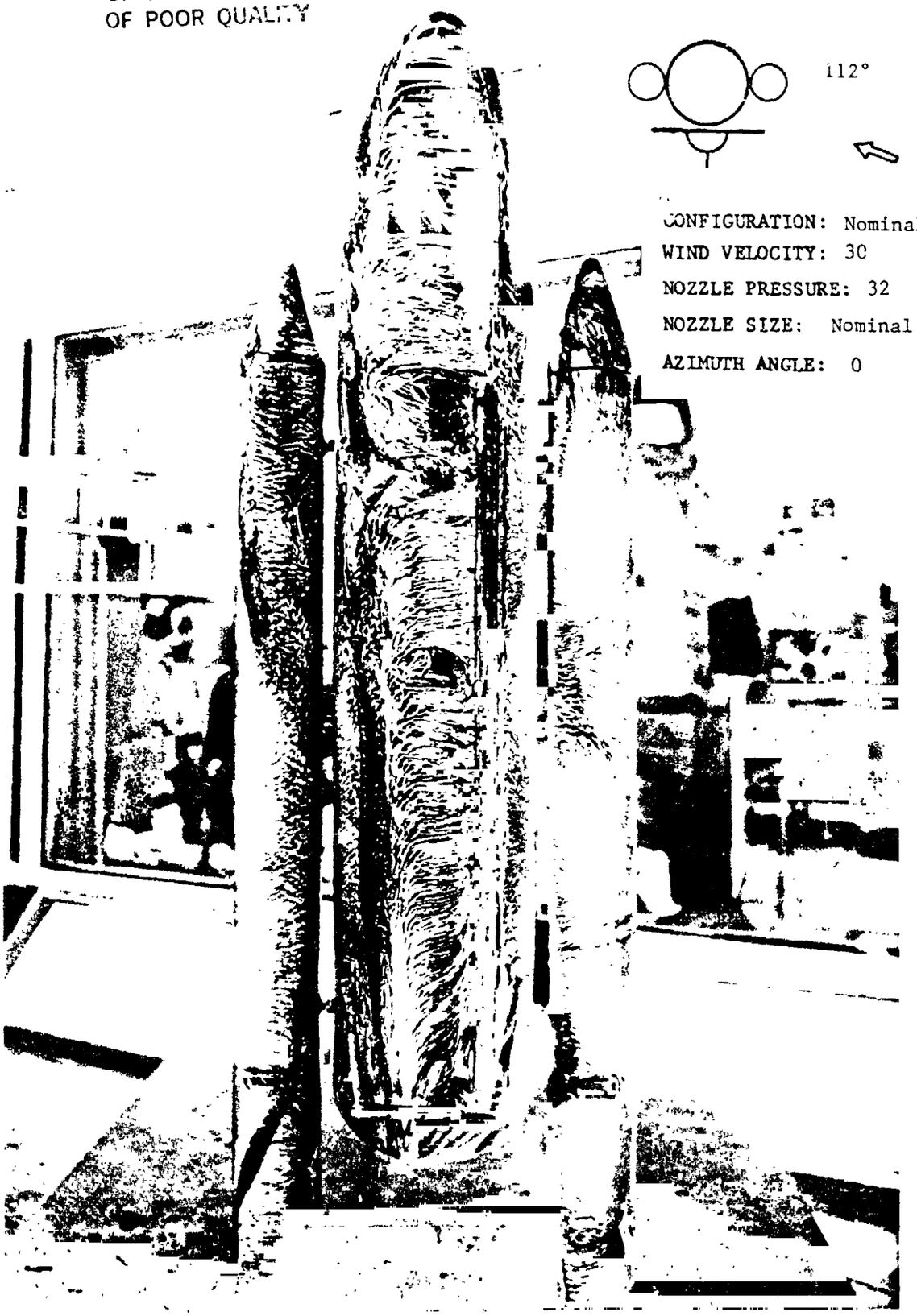
CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 0
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: /

112°

RUN NO. 17

CONFIGURATION: Nominal
WIND VELOCITY: 20
NOZZLE PRESSURE: 0
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: /

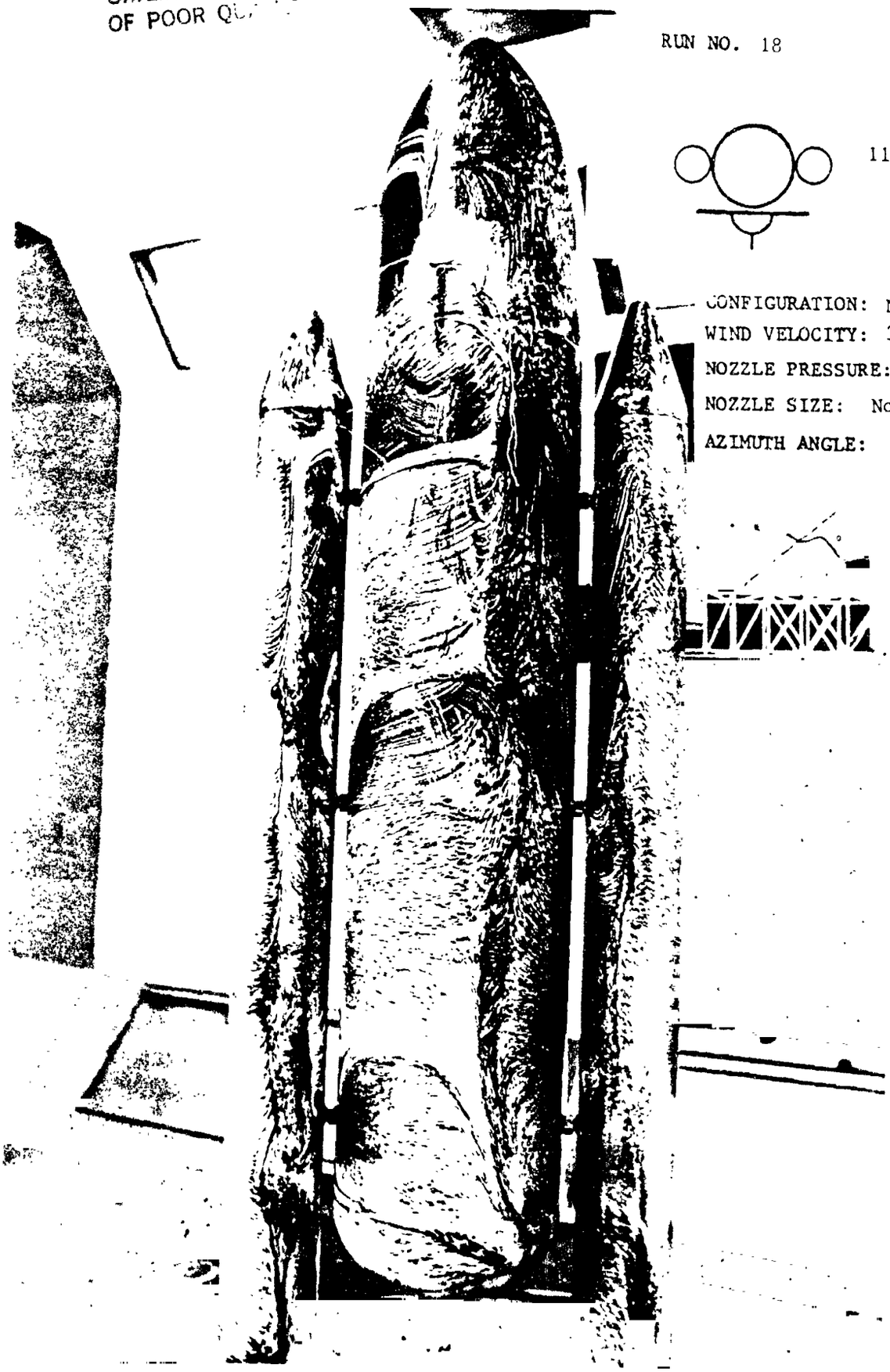
RUN NO. 18



112°

CONFIGURATION: Nominal
WIND VELOCITY: 30
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN NO. 18

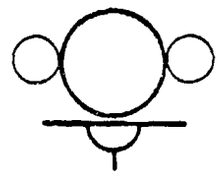


CONFIGURATION: Nominal
WIND VELOCITY: 30
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN NO. 18

CONFIGURATION: Nominal
WIND VELOCITY: 30
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

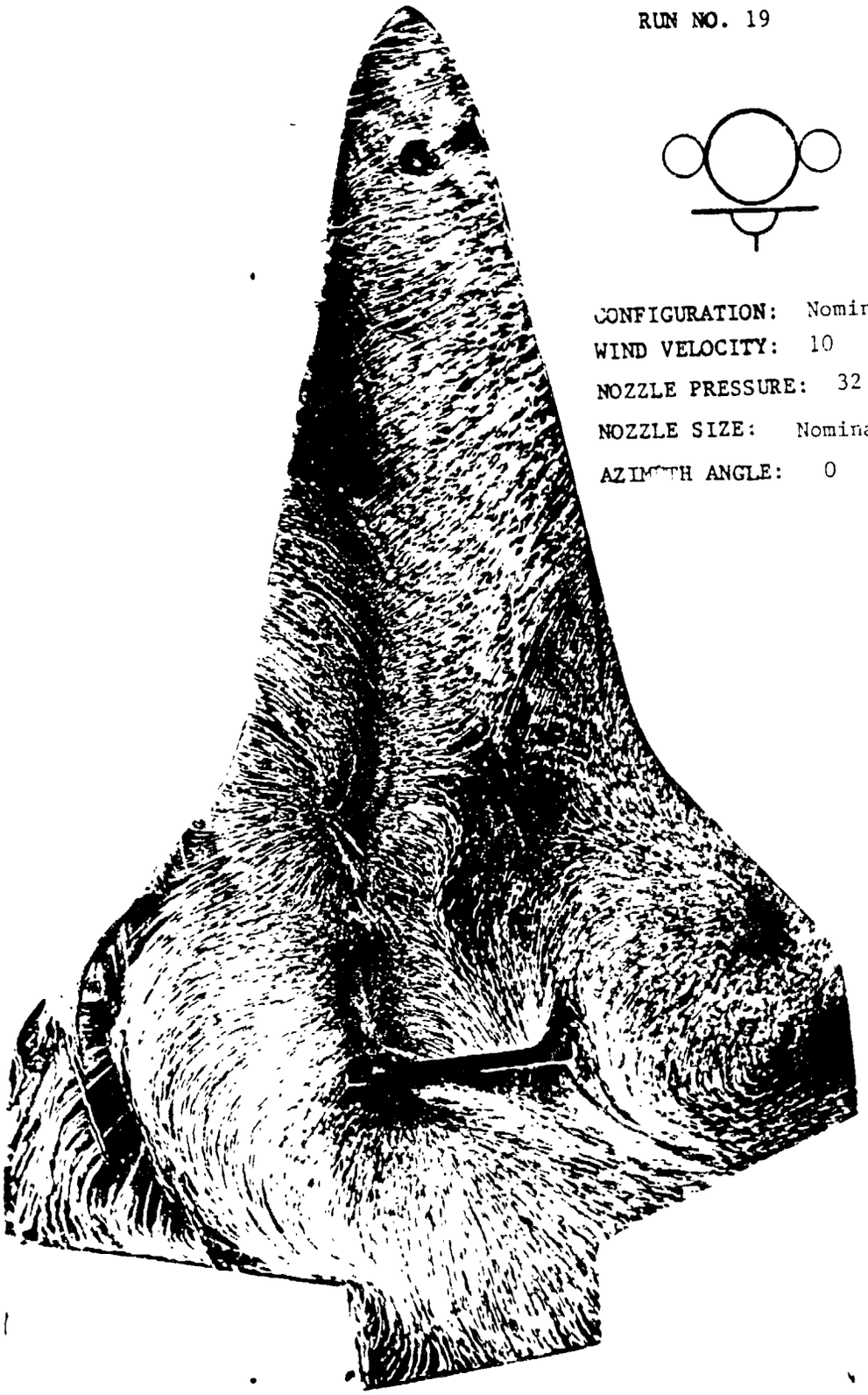
RUN NO. 19



112°

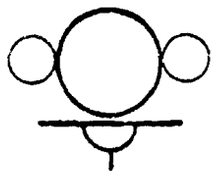
CONFIGURATION: Nominal
WIND VELOCITY: 10
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

RUN NO. 19

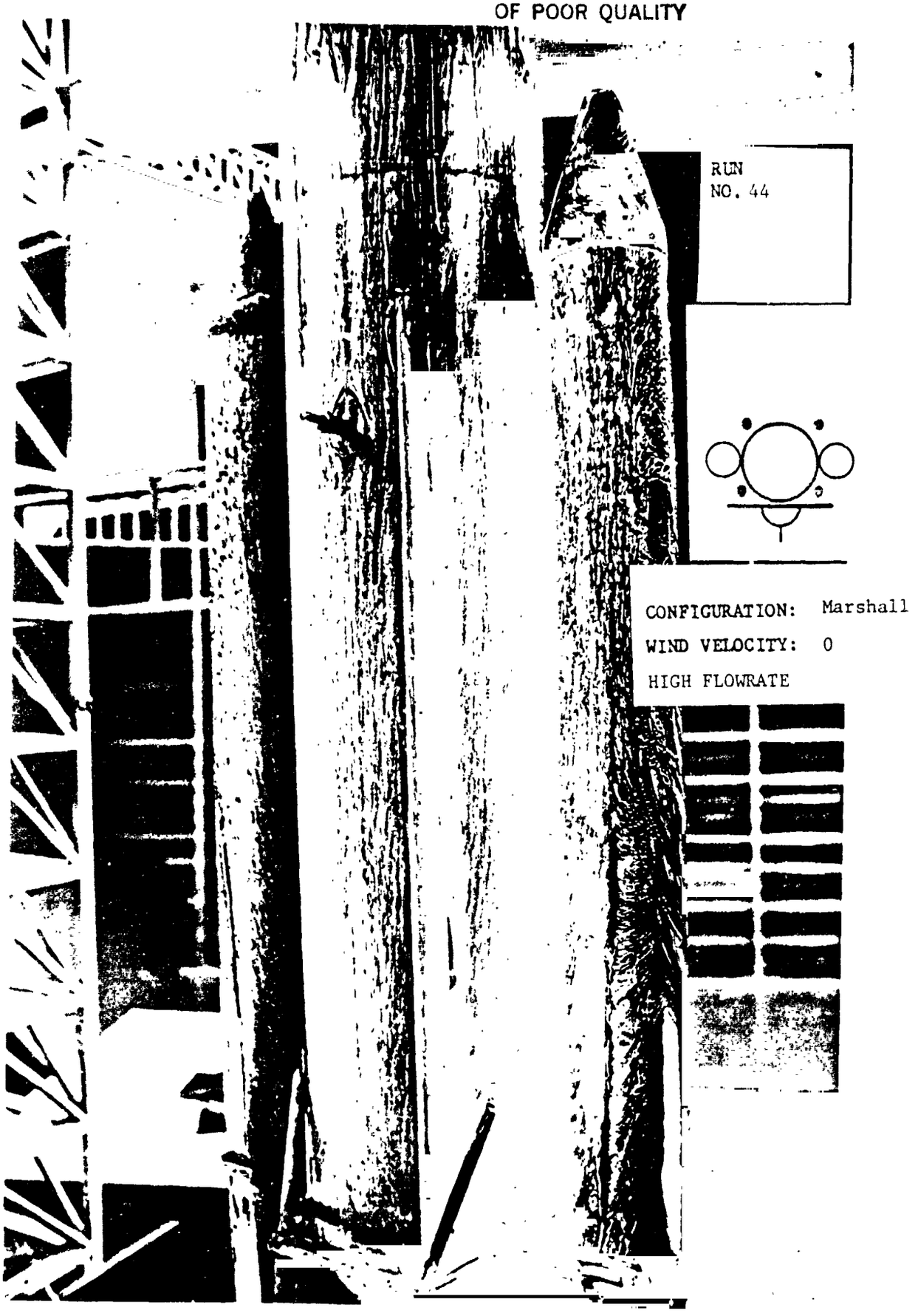


CONFIGURATION: Nominal
WIND VELOCITY: 10
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0

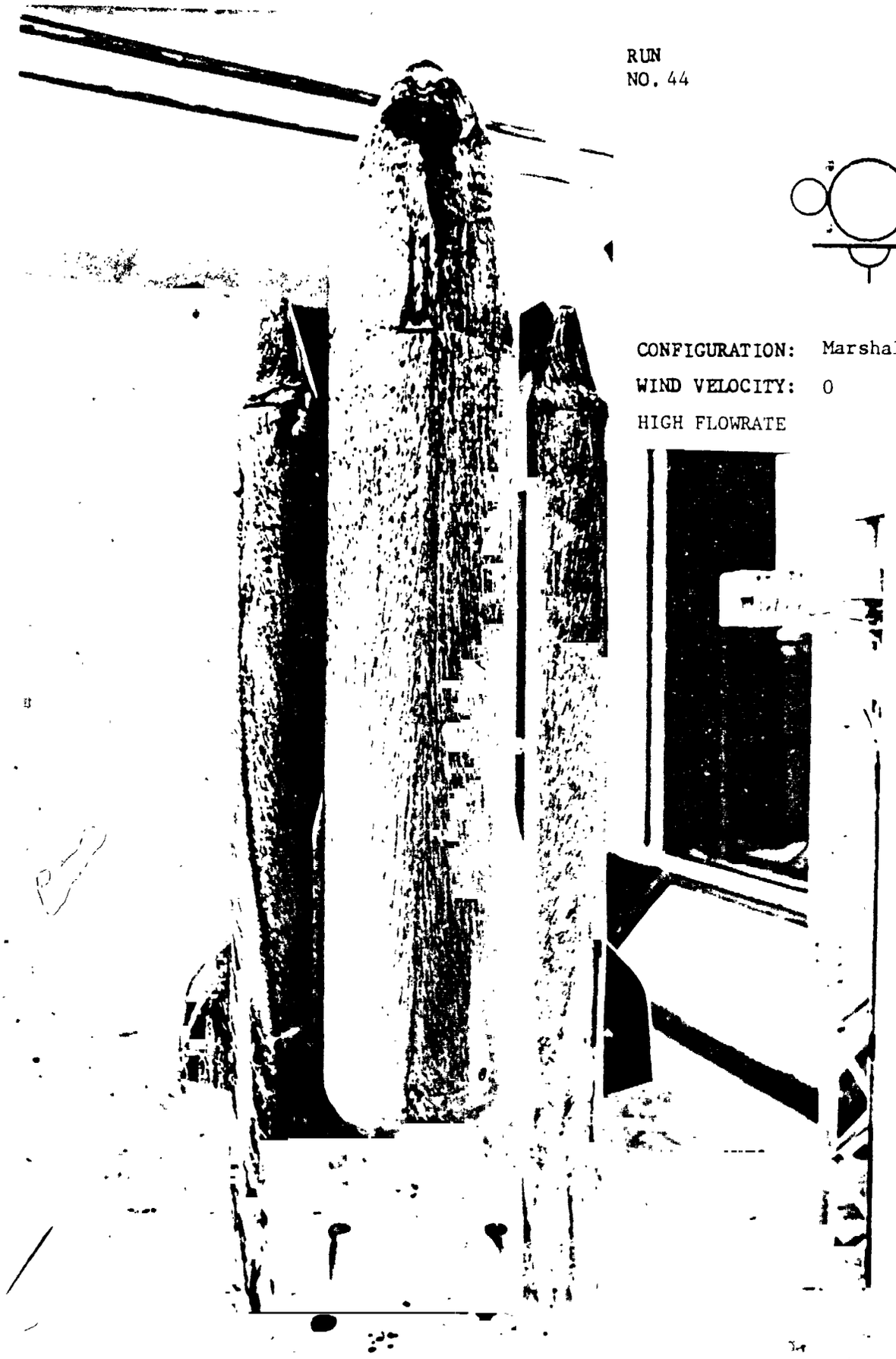
RUN NO. 19



CONFIGURATION: Nominal
WIND VELOCITY: 10
NOZZLE PRESSURE: 32
NOZZLE SIZE: Nominal
AZIMUTH ANGLE: 0



RUN
NO. 44

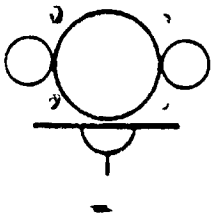


CONFIGURATION: Marshall

WIND VELOCITY: 0

HIGH FLOWRATE

RUN
NO. 44

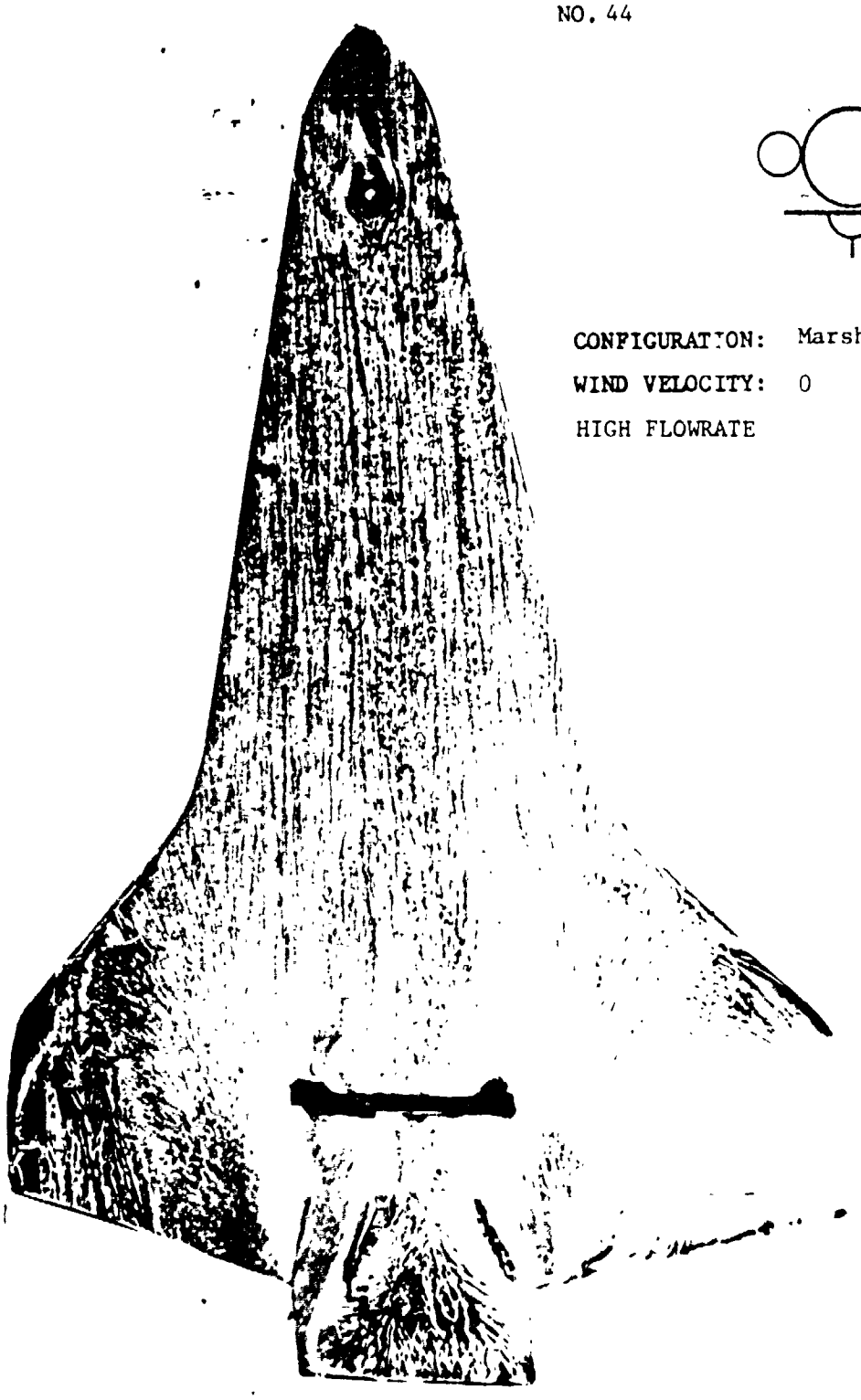


CONFIGURATION: Marshall

WIND VELOCITY: 0

HIGH FLOWRATE

RUN
NO. 44



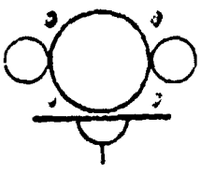
CONFIGURATION: Marshall

WIND VELOCITY: 0

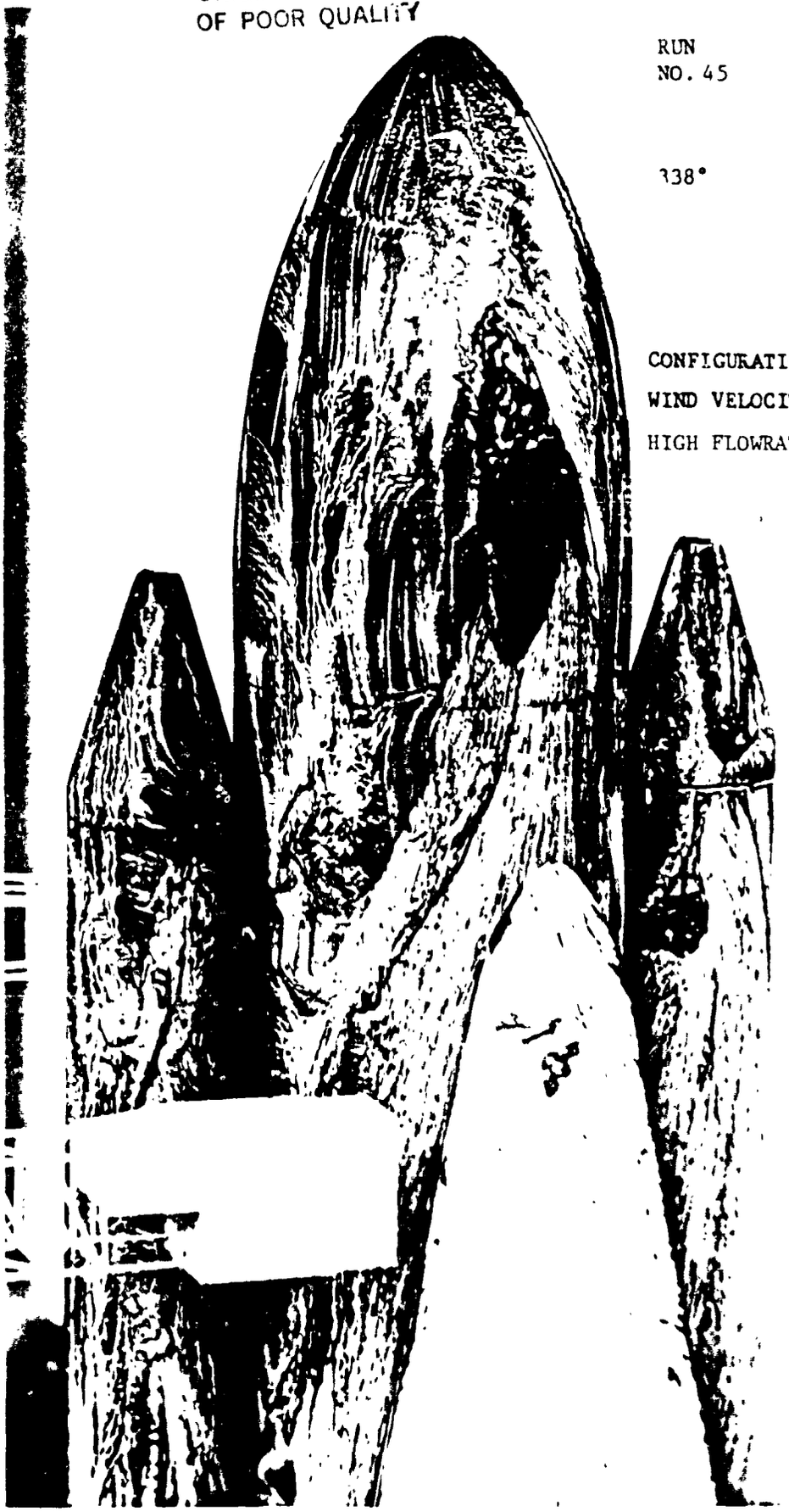
HIGH FLOWRATE

RUN NO. 45

338°

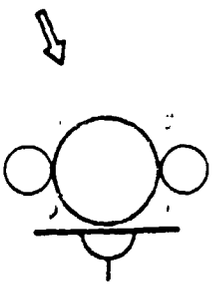


CONFIGURATION: Marshall
WIND VELOCITY: 7
HIGH FLOWRATE



RUN
NO. 45

338°



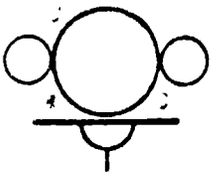
CONFIGURATION: Marshall

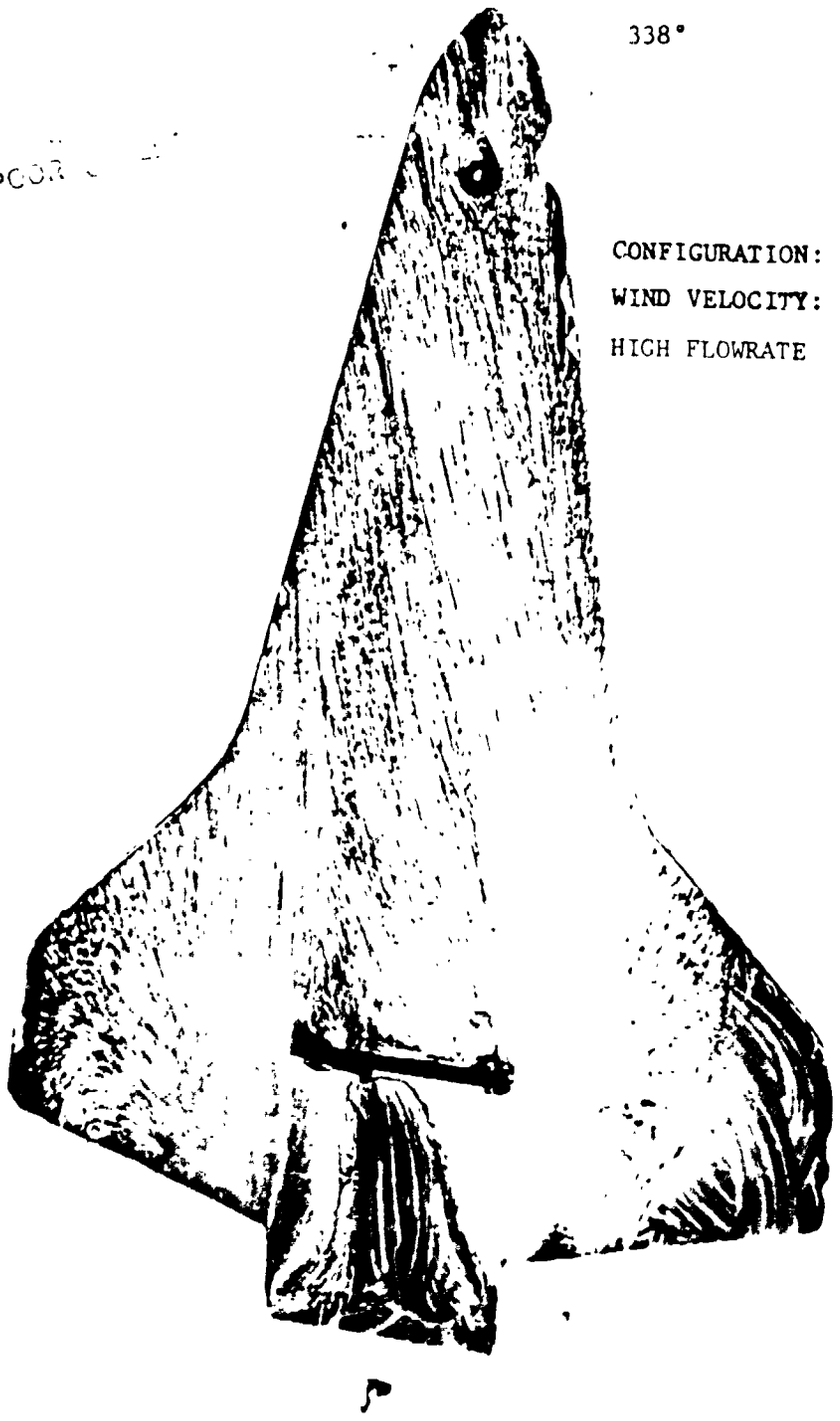
WIND VELOCITY: 7

HIGH FLOWRATE

RUN
NO. 45

338°

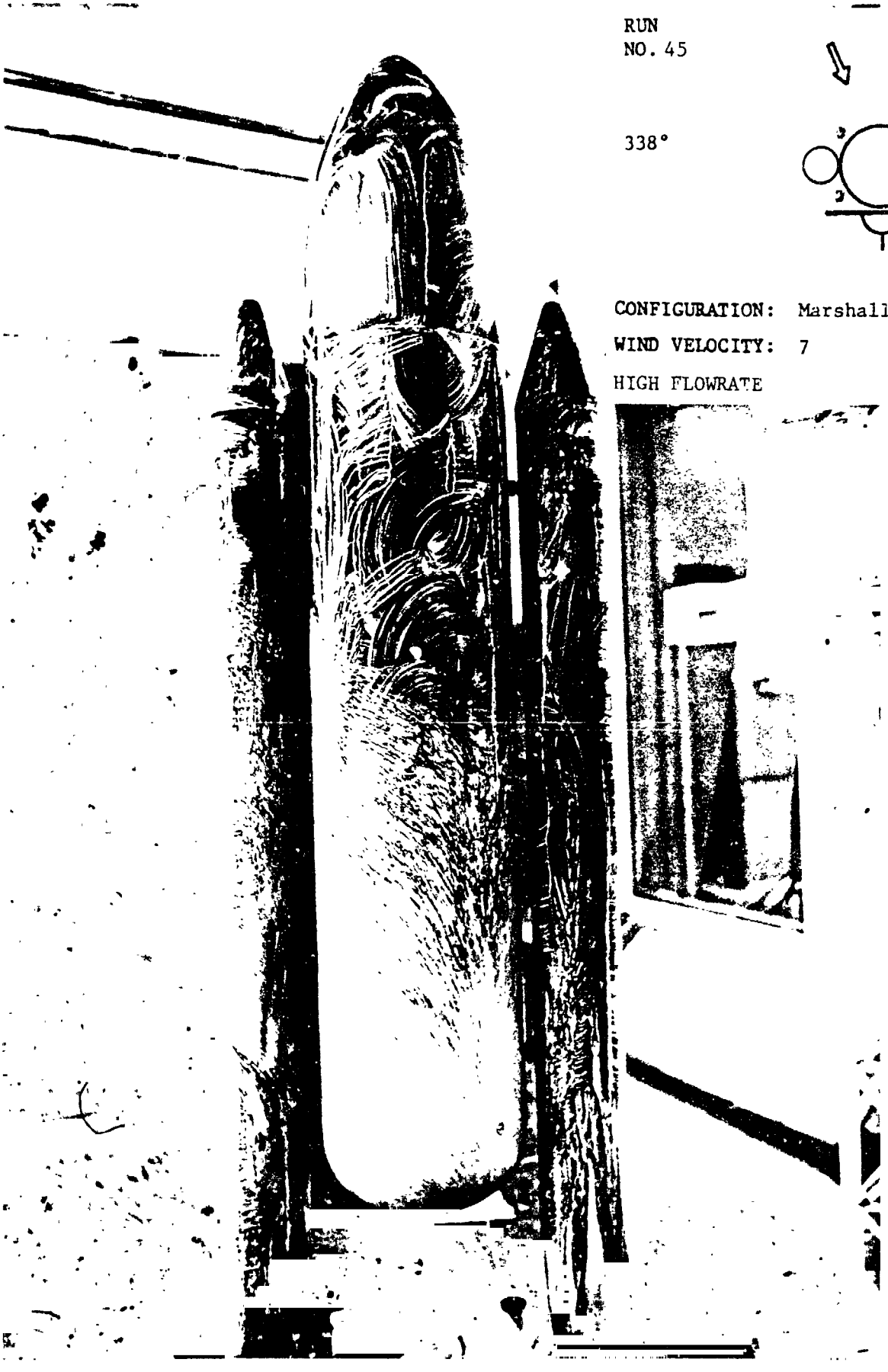




CONFIGURATION: Marshall

WIND VELOCITY: 7

HIGH FLOWRATE



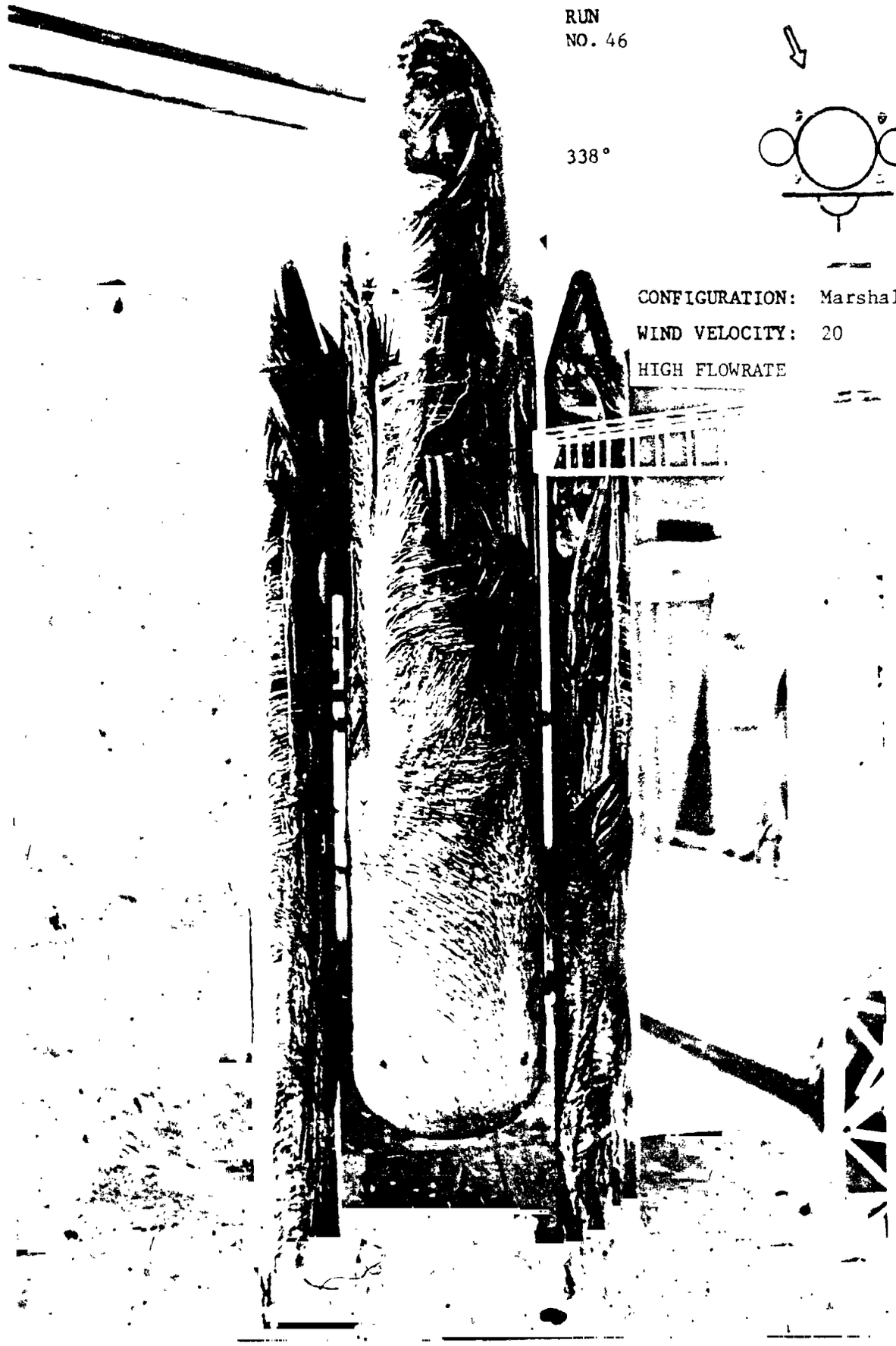
RUN
NO. 45

338°

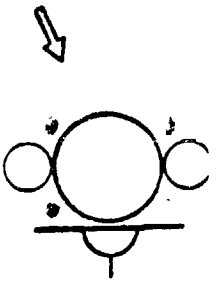
CONFIGURATION: Marshall

WIND VELOCITY: 7

HIGH FLOWRATE



RUN
NO. 46

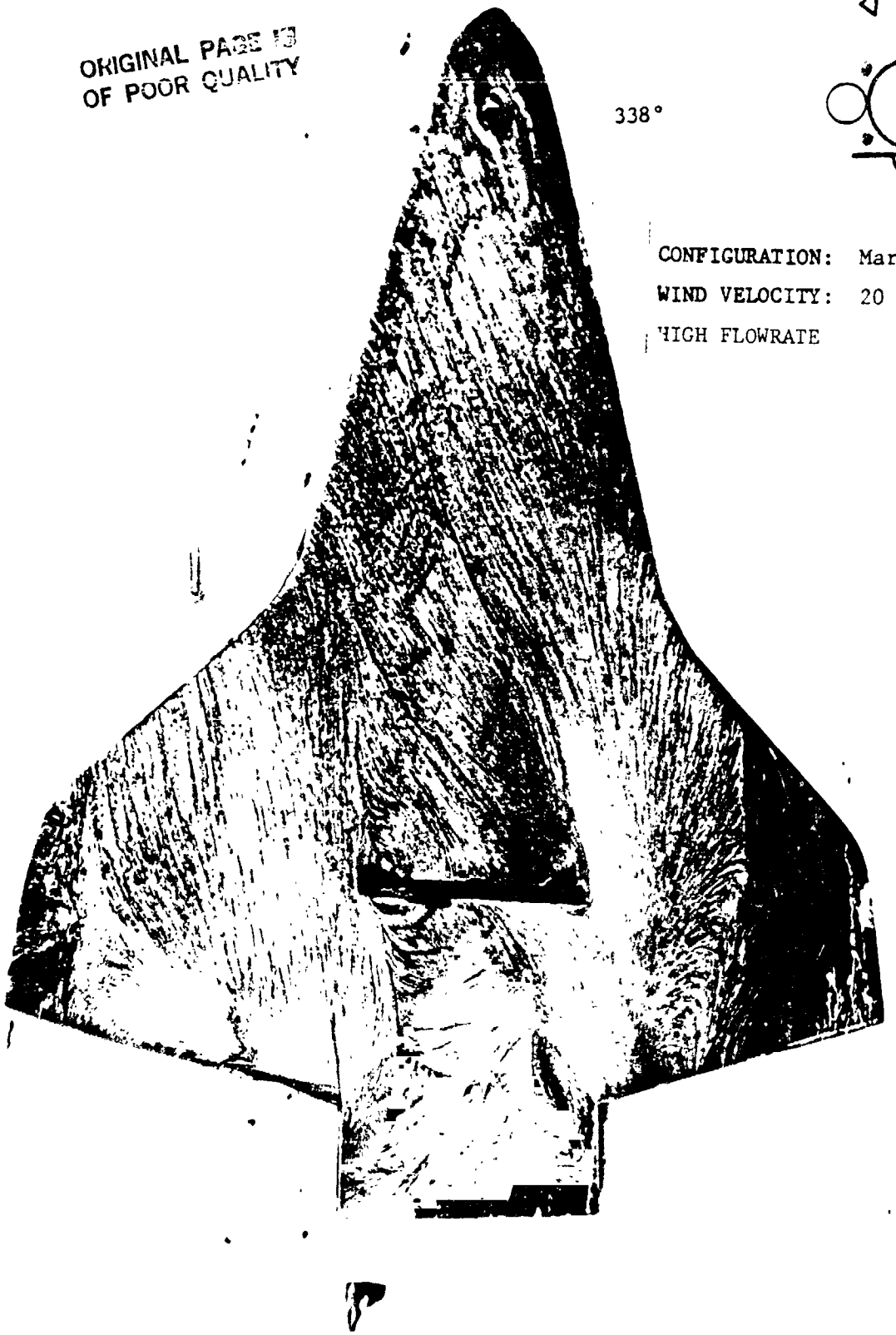


338°

CONFIGURATION: Marshall

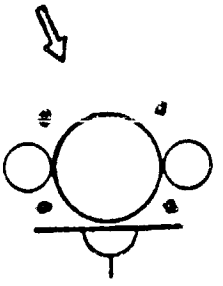
WIND VELOCITY: 20

HIGH FLOWRATE



RUN
NO. 46

338°

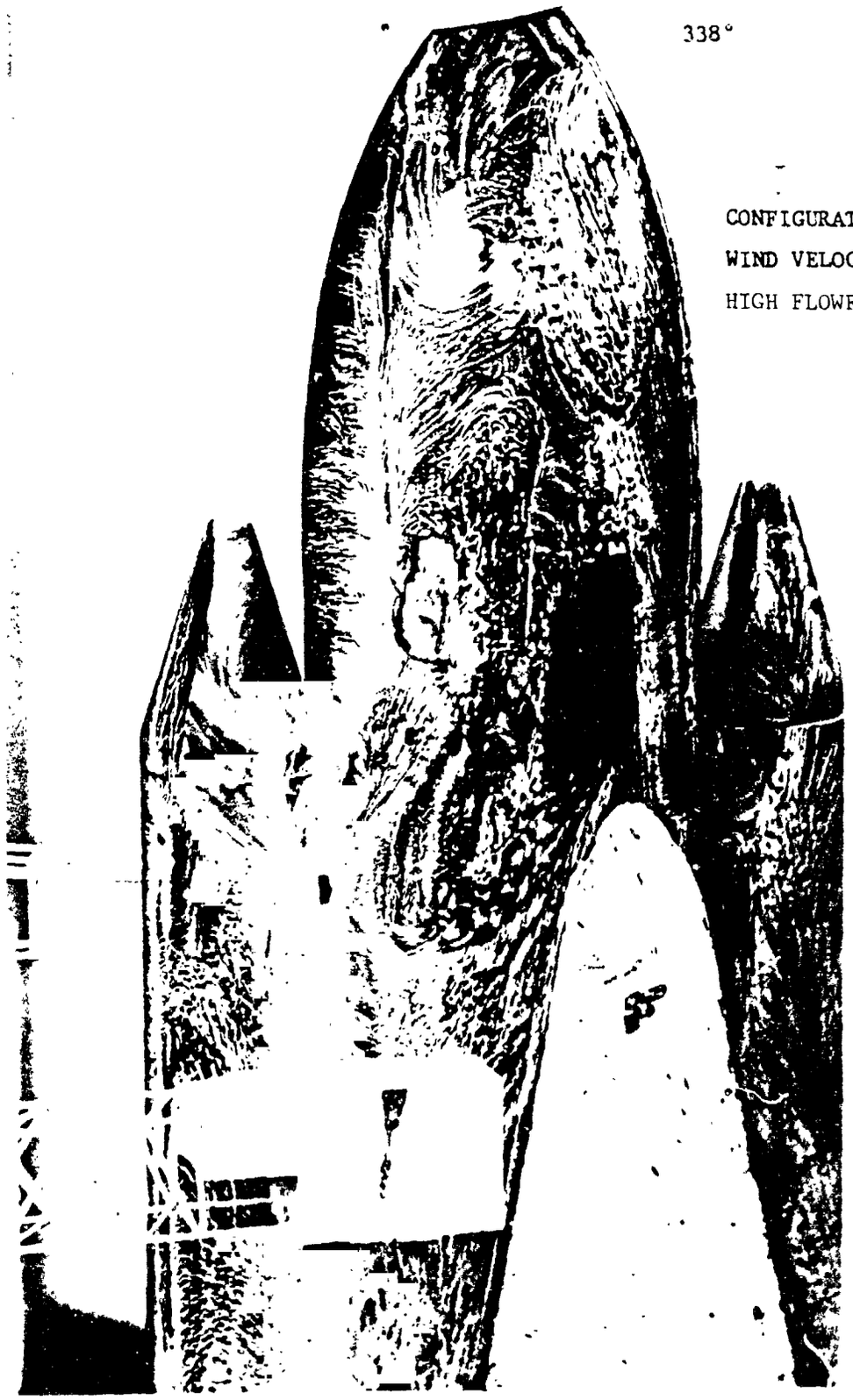


CONFIGURATION: Marshall

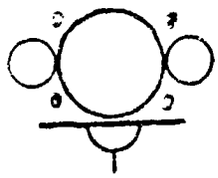
WIND VELOCITY: 20

HIGH FLOWRATE

RUN
NO. 46



338°

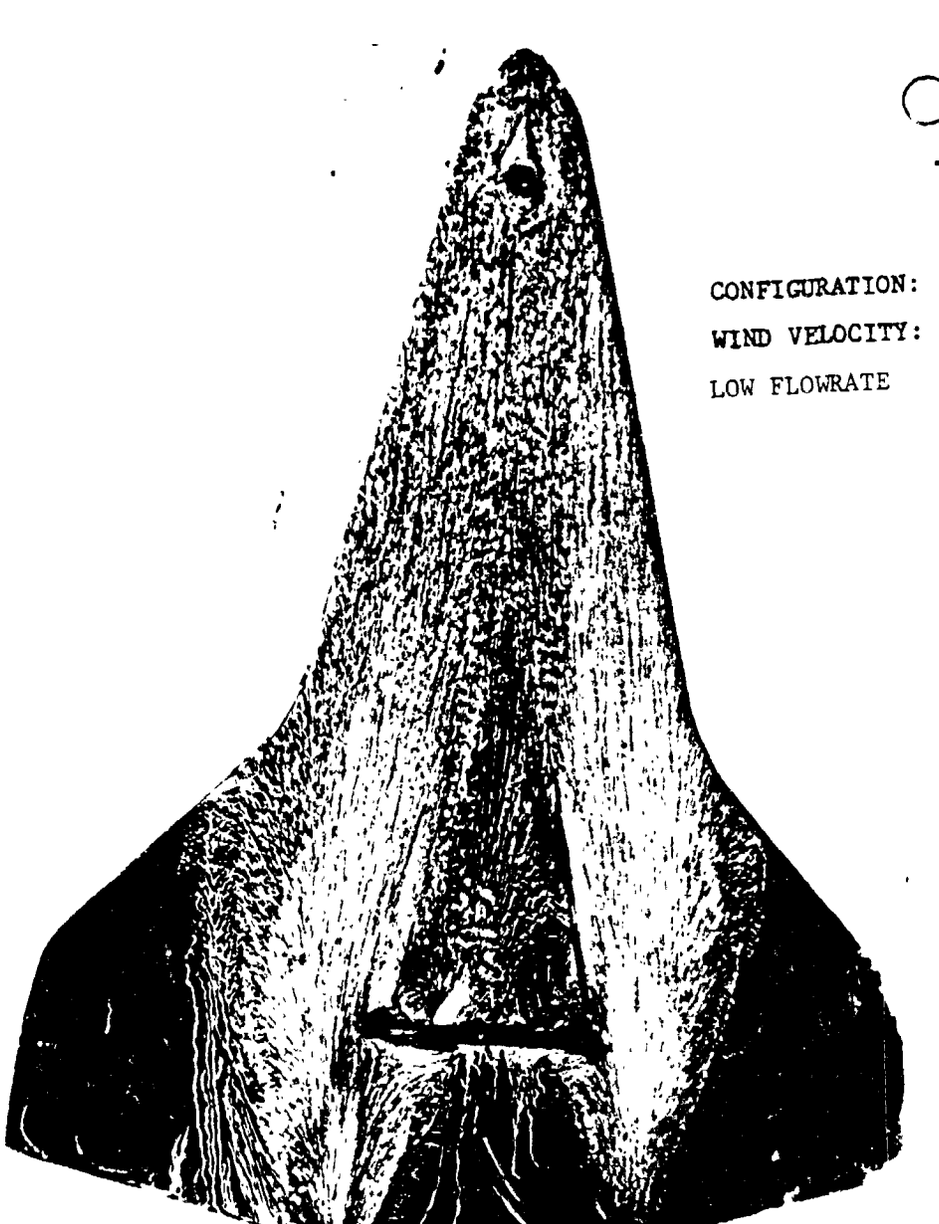


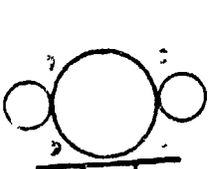
CONFIGURATION: Marshall

WIND VELOCITY: 20

HIGH FLOWRATE

RUN
NO. 47



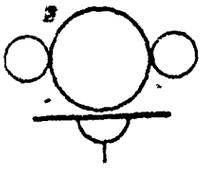


CONFIGURATION: Marshall

WIND VELOCITY: 0

LOW FLOWRATE

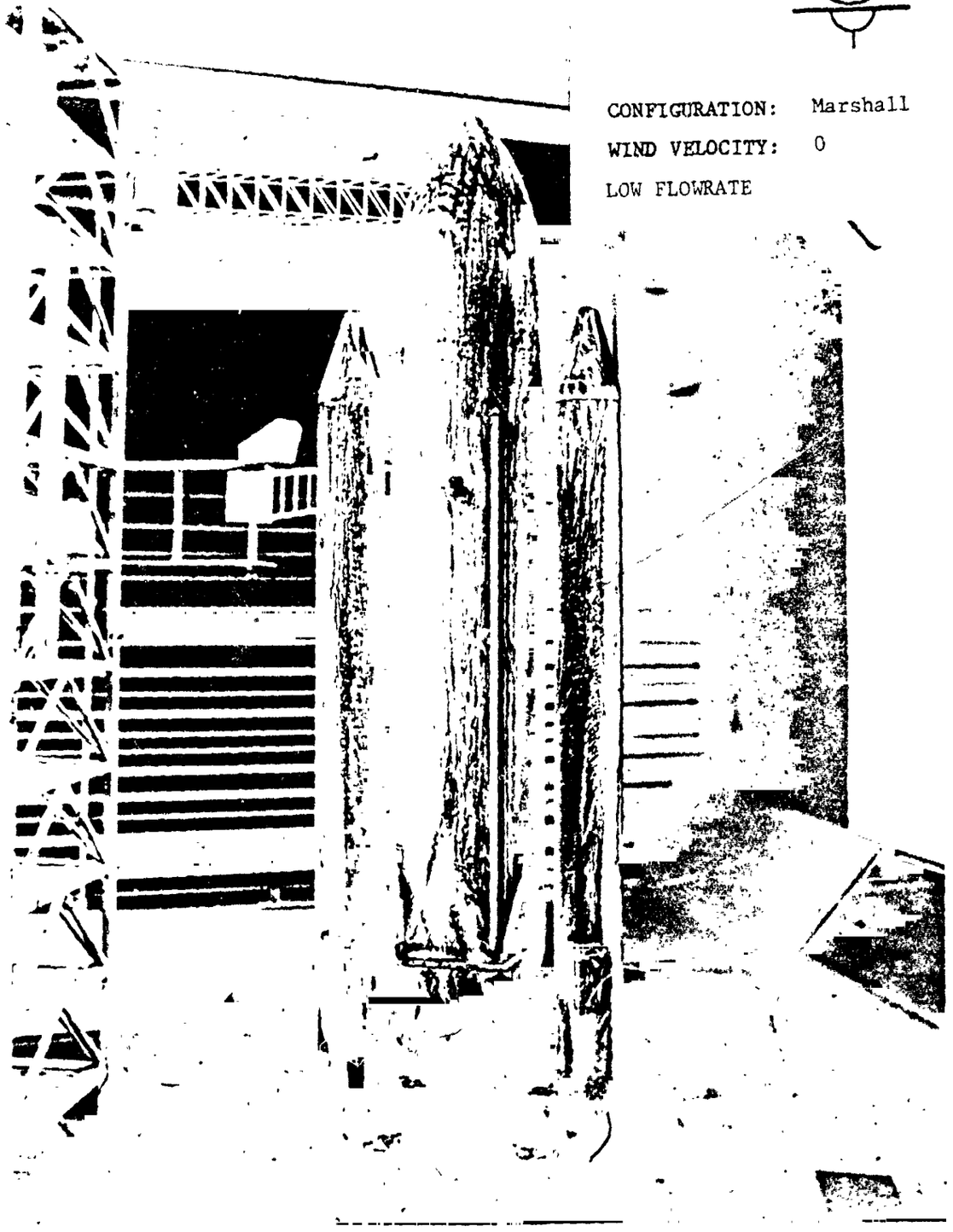
RUN
NO. 47



CONFIGURATION: Marshall

WIND VELOCITY: 0

LOW FLOWRATE



RUN
NO. 47

CONFIGURATION: Marshall

WIND VELOCITY: 0

LOW FLOWRATE

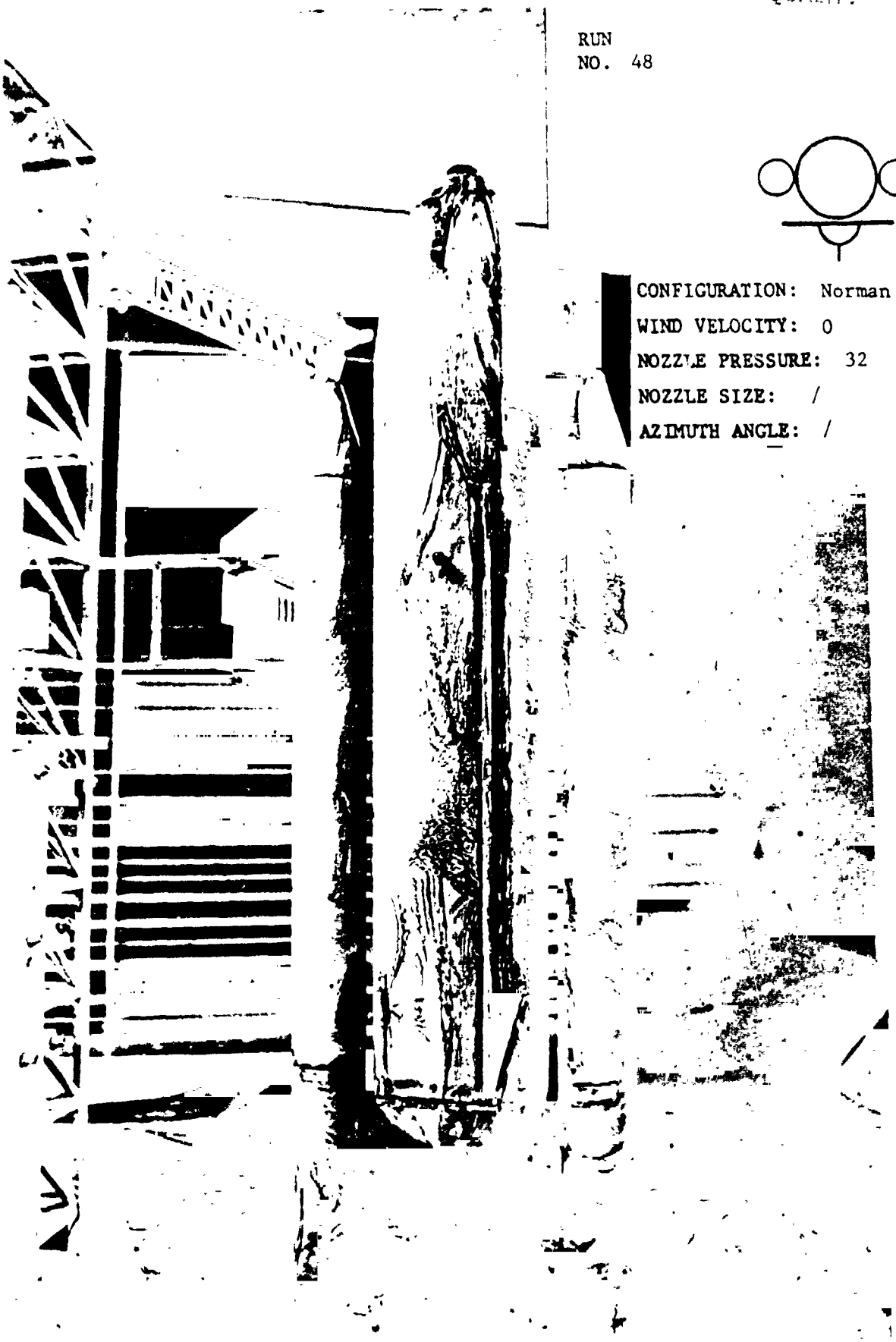
RUN
NO. 48

CONFIGURATION: Norman Eng.
WIND VELOCITY: 0
NOZZLE PRESSURE: 32
NOZZLE SIZE: /
AZIMUTH ANGLE: /

RUN
NO. 48

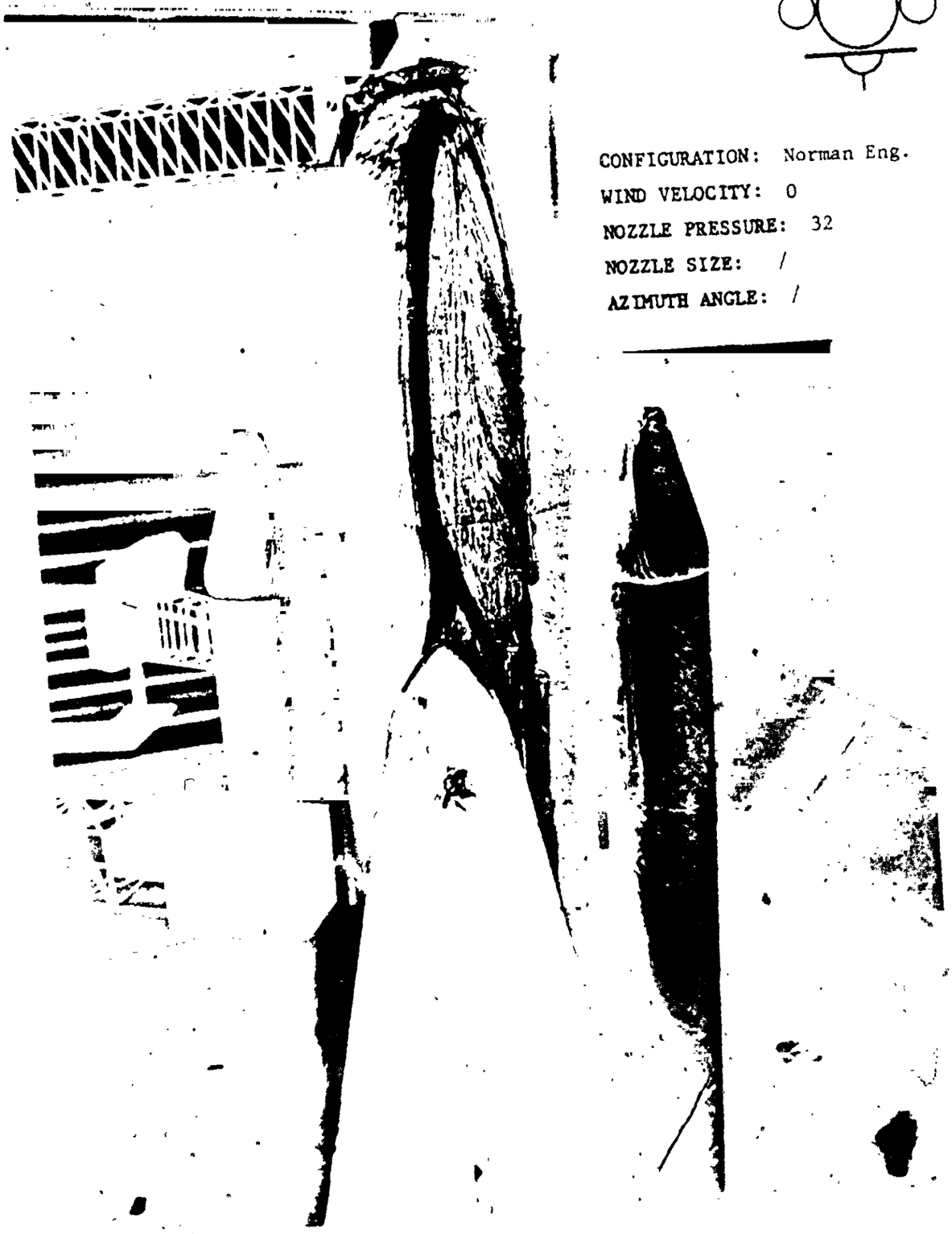
CONFIGURATION: Norman Eng.
WIND VELOCITY: 0
NOZZLE PRESSURE: 32
NOZZLE SIZE: /
AZIMUTH ANGLE: /

RUN
NO. 48



CONFIGURATION: Norman Eng.
WIND VELOCITY: 0
NOZZLE PRESSURE: 32
NOZZLE SIZE: /
AZIMUTH ANGLE: /

RUN
NO. 48



CONFIGURATION: Norman Eng.
WIND VELOCITY: 0
NOZZLE PRESSURE: 32
NOZZLE SIZE: /
AZIMUTH ANGLE: /

CONFIGURATION: Norman Eng.

WIND VELOCITY: 0

NOZZLE PRESSURE: 32

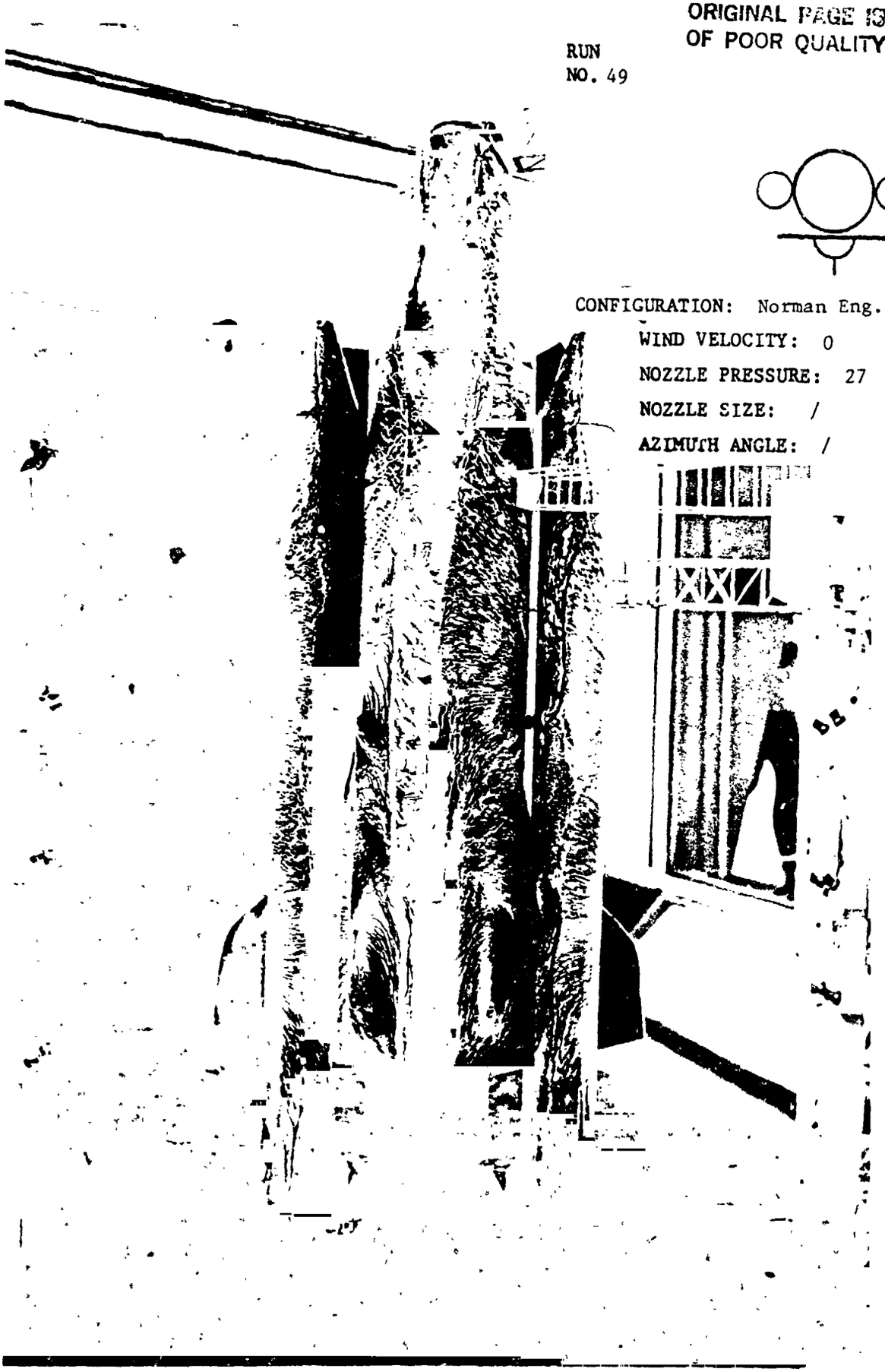
AZIMUTH ANGLE: 0

RUN
NO. 48

RUN
NO. 49

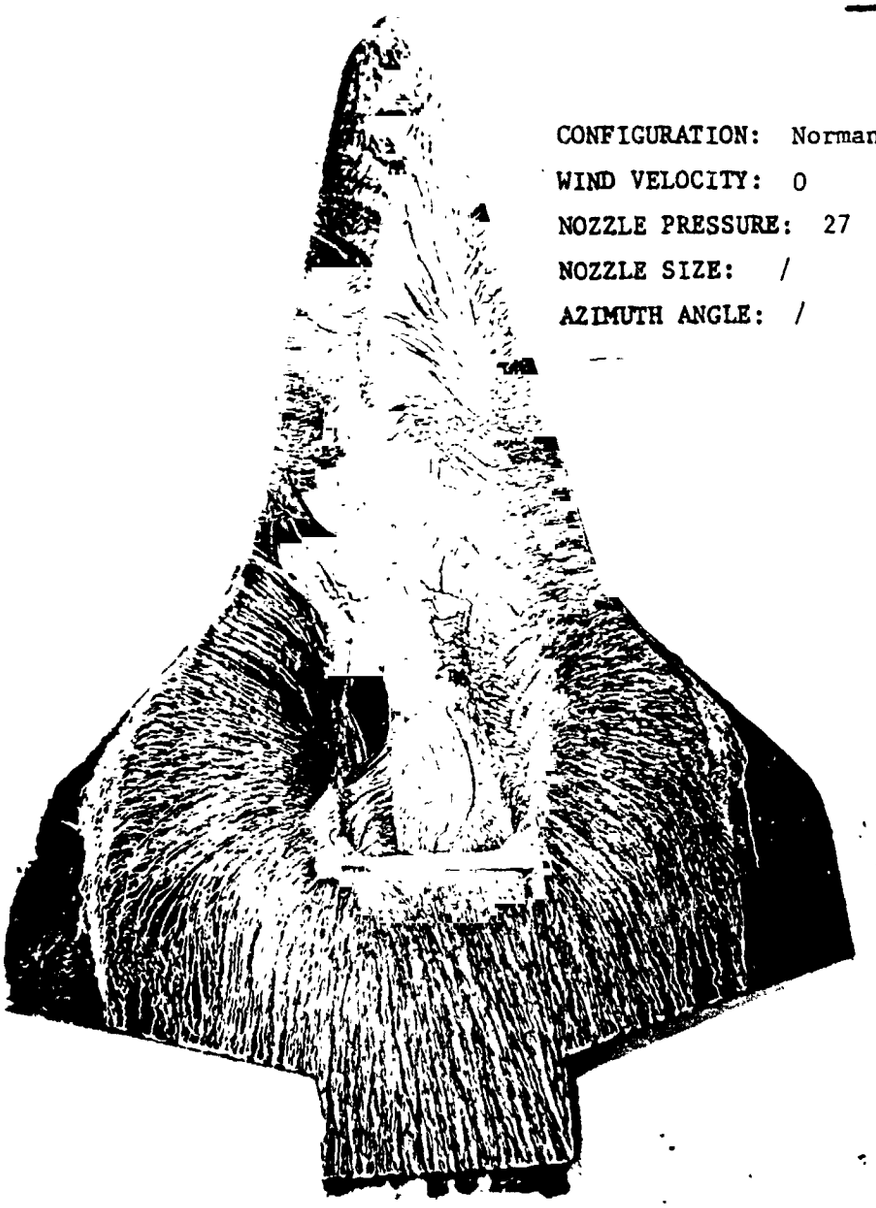
CONFIGURATION: Norman Eng.
WIND VELOCITY: 0
NOZZLE PRESSURE: 27
NOZZLE SIZE: /
AZIMUTH ANGLE: /

RUN
NO. 49



CONFIGURATION: Norman Eng.
WIND VELOCITY: 0
NOZZLE PRESSURE: 27
NOZZLE SIZE: /
AZIMUTH ANGLE: /

RUN
NO. 49



CONFIGURATION: Norman Eng.

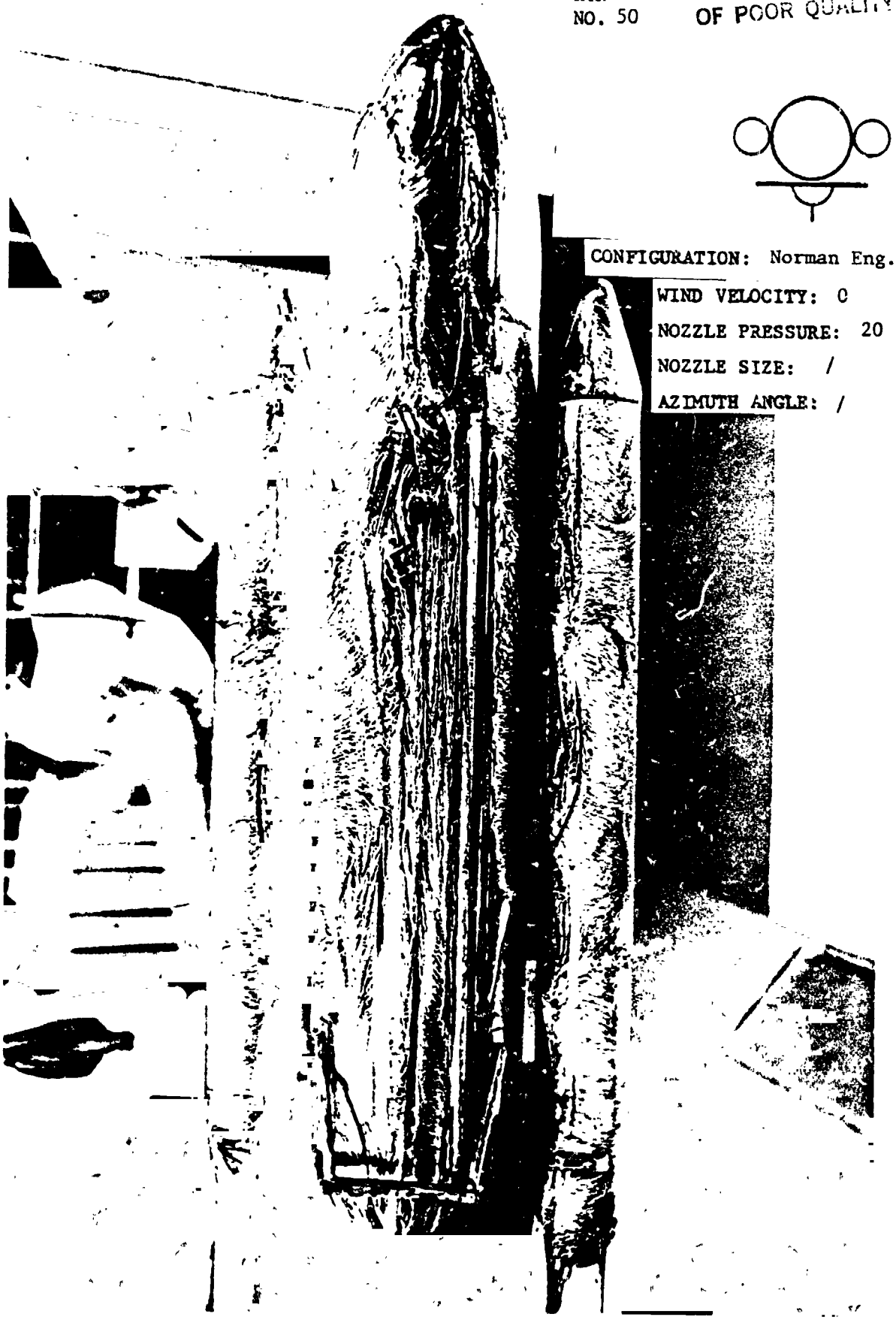
WIND VELOCITY: 0

NOZZLE PRESSURE: 27

NOZZLE SIZE: /

AZIMUTH ANGLE: /

RUN
NO. 50



CONFIGURATION: Norman Eng.
WIND VELOCITY: 0
NOZZLE PRESSURE: 20
NOZZLE SIZE: /
AZIMUTH ANGLE: /

RUN
NO. 50

CONFIGURATION: Norman Eng.

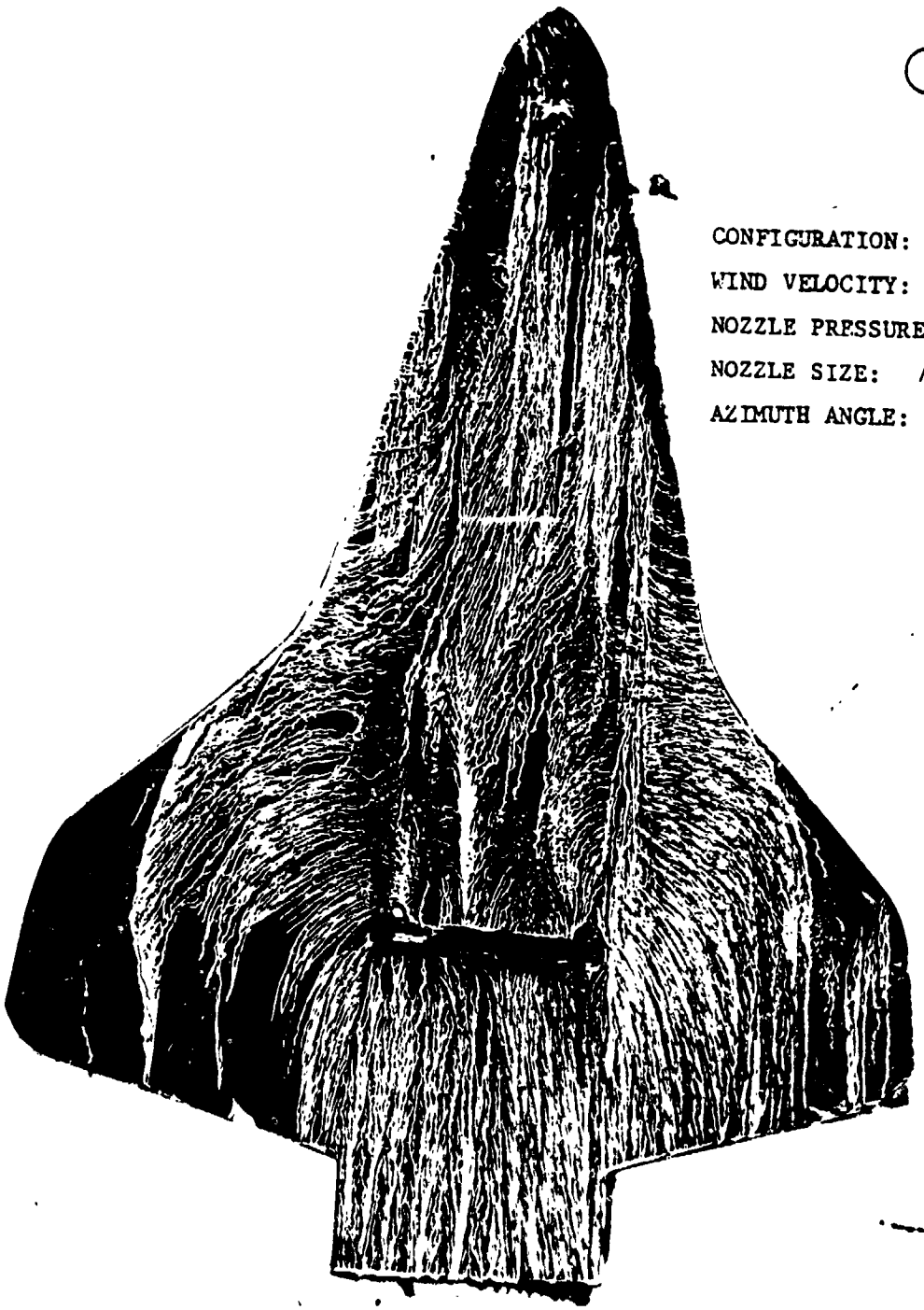
WIND VELOCITY: 0

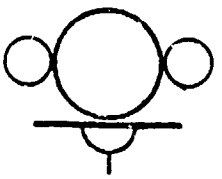
NOZZLE PRESSURE: 20

NOZZLE SIZE: /

AZIMUTH ANGLE: /

RUN
NO. 50





CONFIGURATION: Norman Eng.

WIND VELOCITY: 0

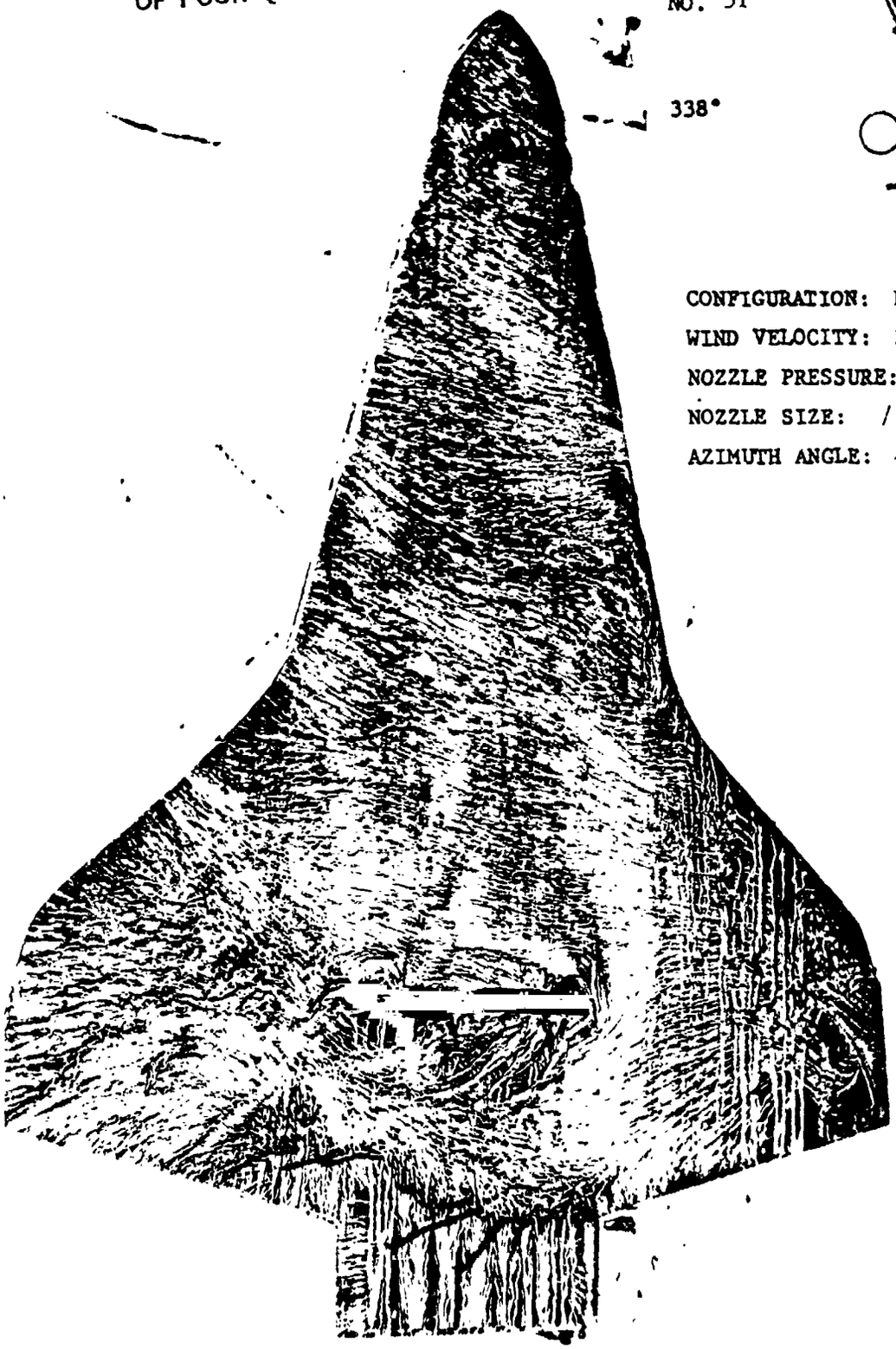
NOZZLE PRESSURE: 20

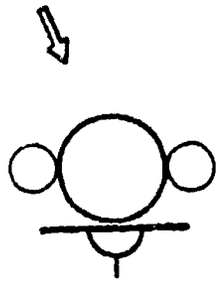
NOZZLE SIZE: /

AZIMUTH ANGLE: /

RUN
NO. 51

338°

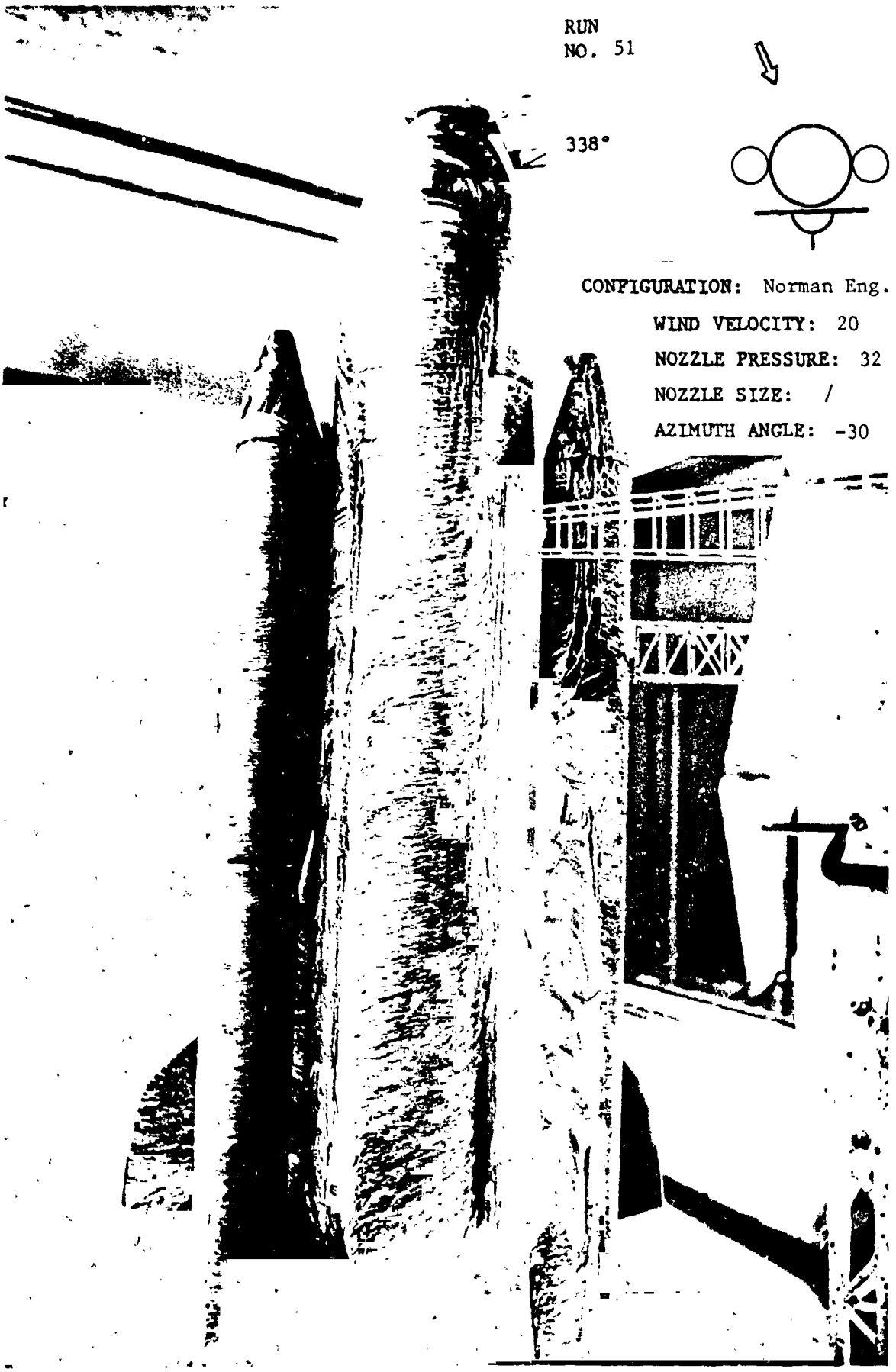




CONFIGURATION: Norman Eng.
WIND VELOCITY: 20
NOZZLE PRESSURE: 32
NOZZLE SIZE: /
AZIMUTH ANGLE: -30

RUN
NO. 51

338°



CONFIGURATION: Norman Eng.
WIND VELOCITY: 20
NOZZLE PRESSURE: 32
NOZZLE SIZE: /
AZIMUTH ANGLE: -30

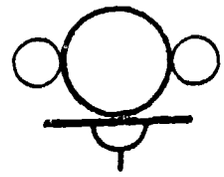
RUN
NO. 51

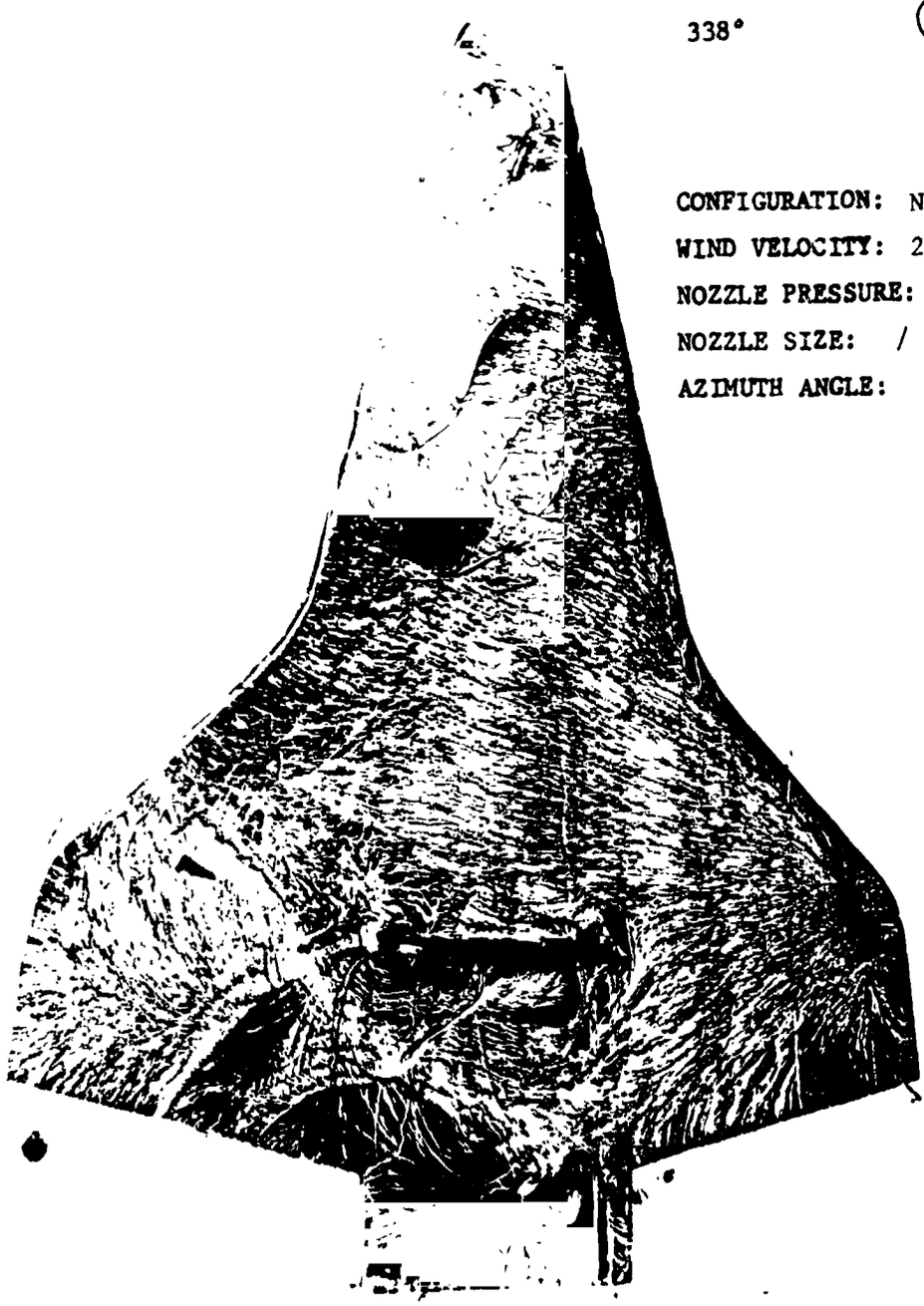
338°

CONFIGURATION: Norman Eng.
WIND VELOCITY: 20
NOZZLE PRESSURE: 32
NOZZLE SIZE: /
AZIMUTH ANGLE: -30

RUN
NO. 52

338°





CONFIGURATION: Norman Eng.

WIND VELOCITY: 20

NOZZLE PRESSURE: 27

NOZZLE SIZE: /

AZIMUTH ANGLE: -30

RUN
NO. 52

338°

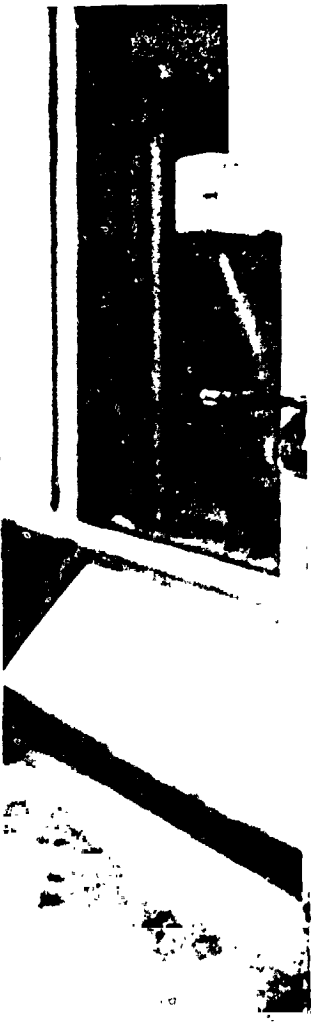
CONFIGURATION: Norman Eng.

WIND VELOCITY: 20

NOZZLE PRESSURE: 27

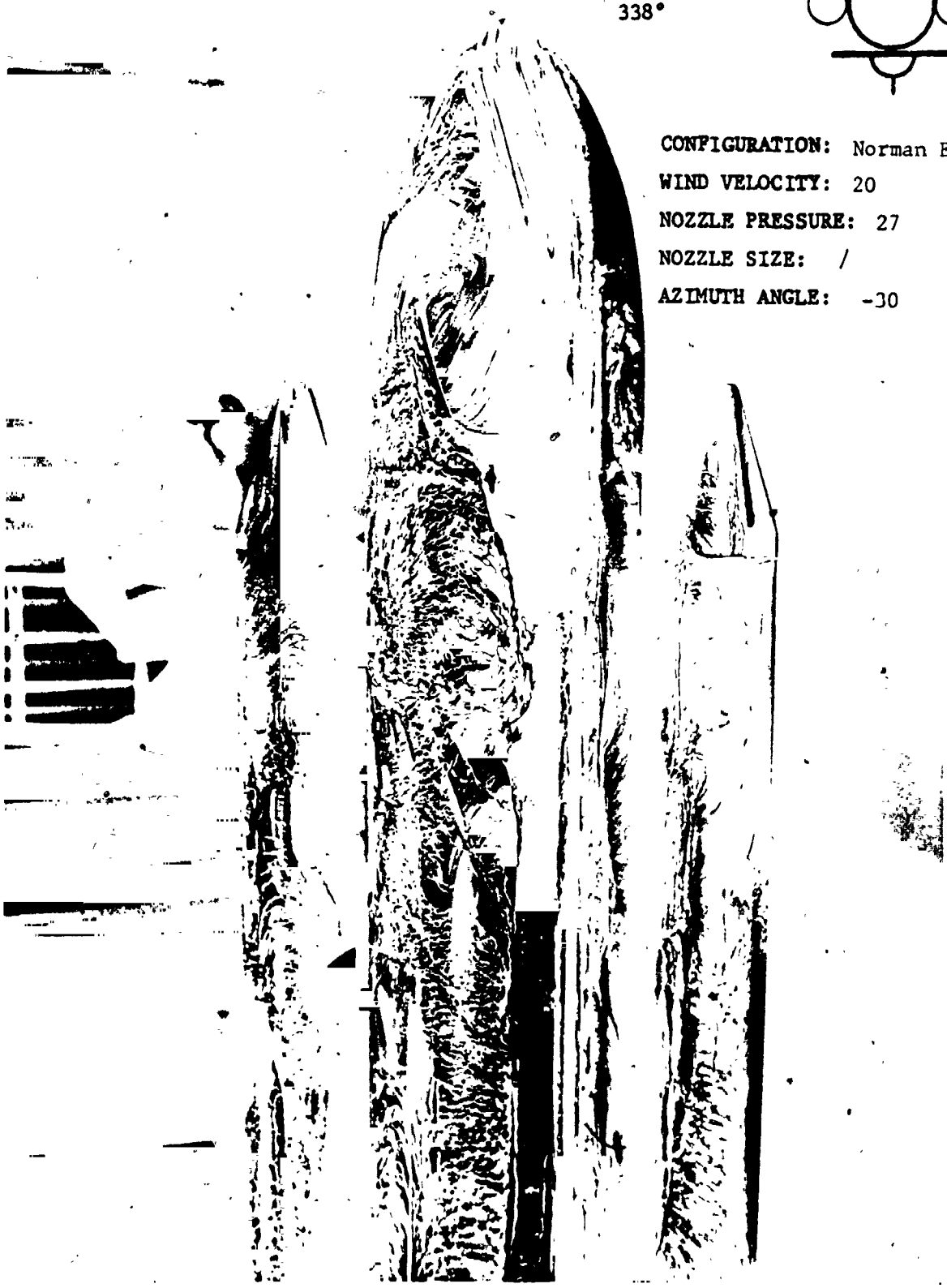
NOZZLE SIZE: /

AZIMUTH ANGLE: 30



RUN
NO. 52

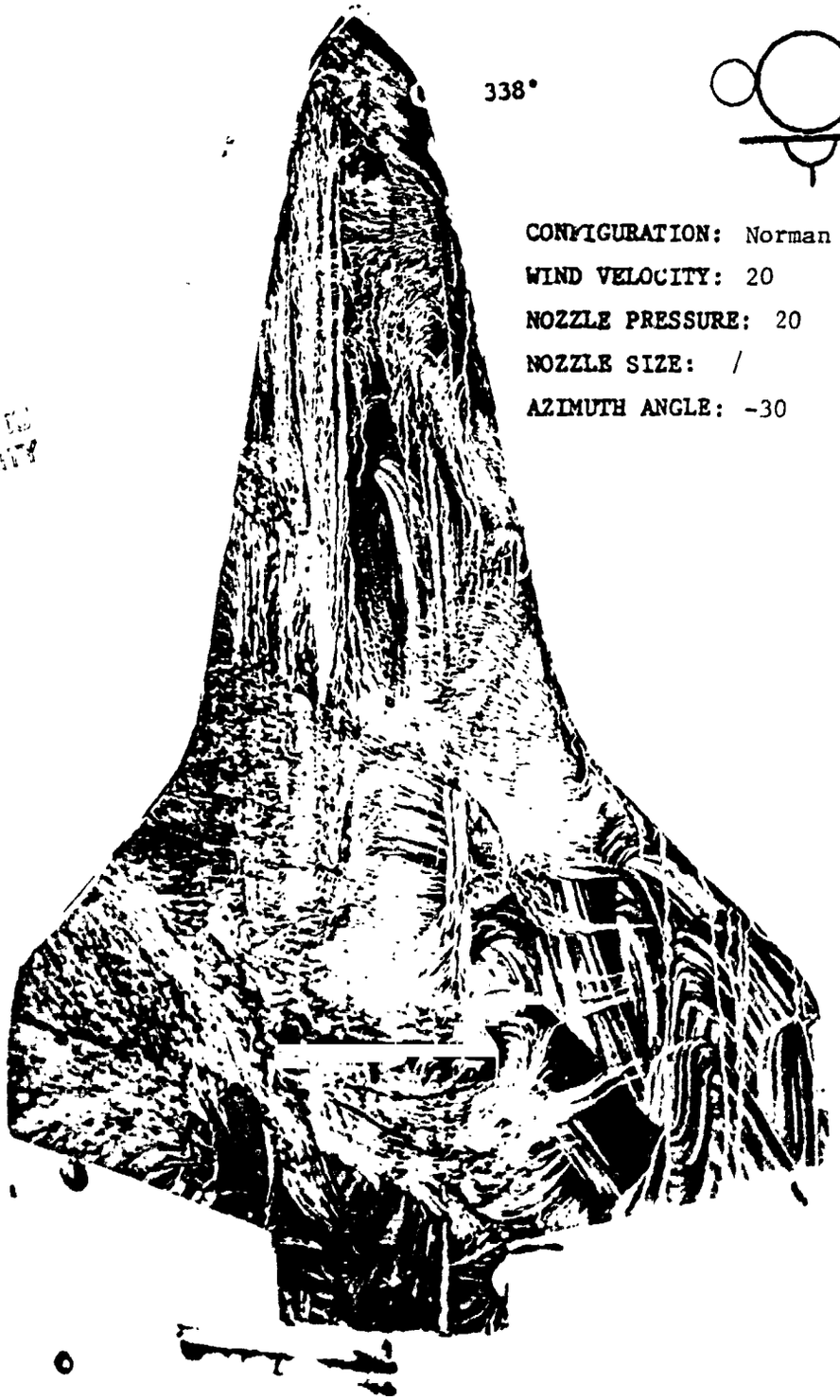
338°



CONFIGURATION: Norman Eng.
WIND VELOCITY: 20
NOZZLE PRESSURE: 27
NOZZLE SIZE: /
AZIMUTH ANGLE: -30

RUN
NO. 53

338°



CONFIGURATION: Norman Eng.

WIND VELOCITY: 20

NOZZLE PRESSURE: 20

NOZZLE SIZE: /

AZIMUTH ANGLE: -30

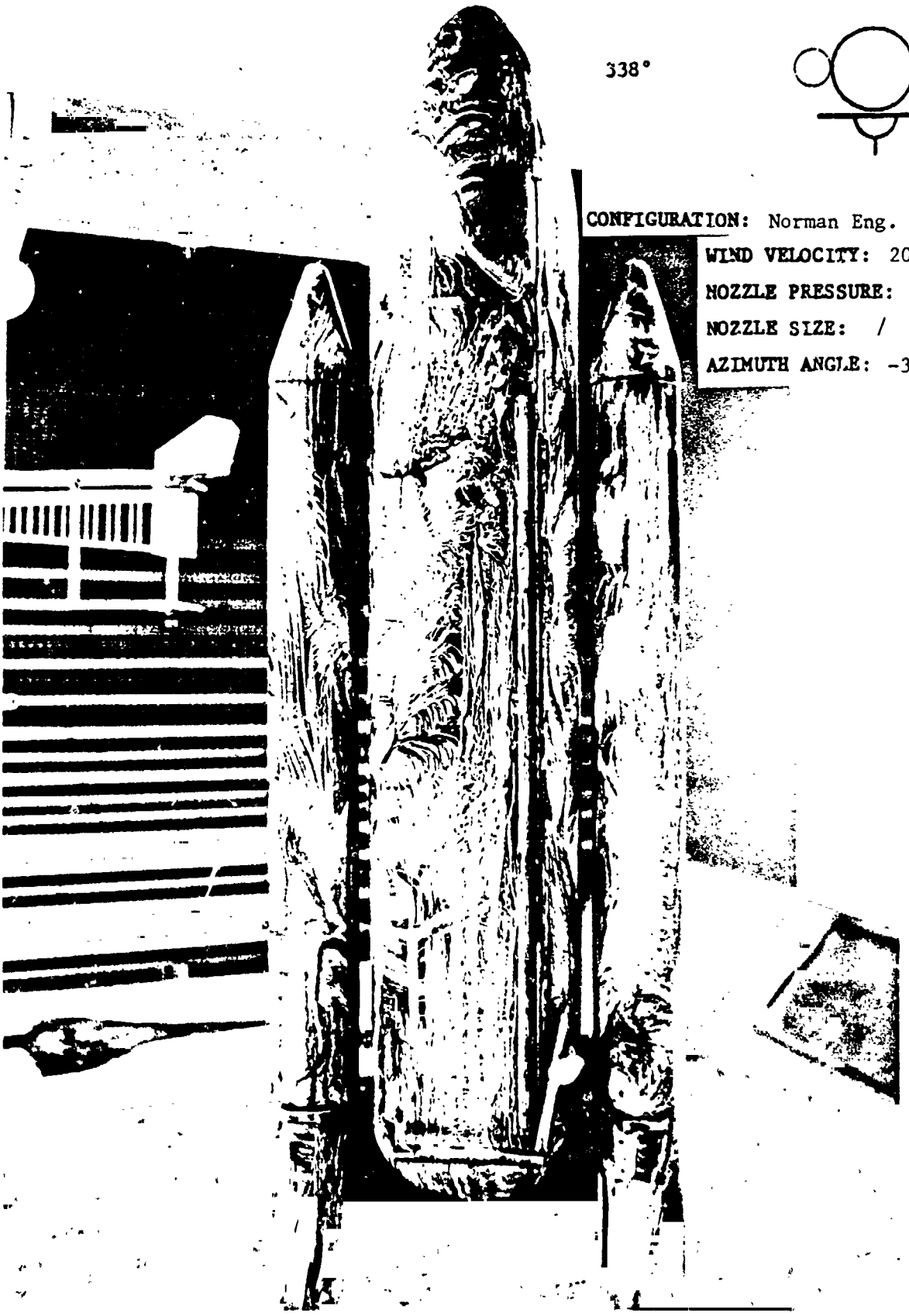
RUN
NO. 53

338°

CONFIGURATION: Norman Eng.
WIND VELOCITY: 20
NOZZLE PRESSURE: 20
NOZZLE SIZE: /
AZIMUTH ANGLE: -30

RUN
NO. 53

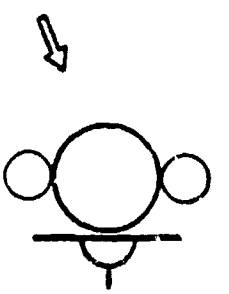
338°



CONFIGURATION: Norman Eng.
WIND VELOCITY: 20
NOZZLE PRESSURE: 20
NOZZLE SIZE: /
AZIMUTH ANGLE: -30

RUN
NO. 53

338°



CONFIGURATION: Norman Eng.

WIND VELOCITY: 20

NOZZLE PRESSURE: 20

NOZZLE SIZE: /

AZIMUTH ANGLE: -30